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# Insect Suppression in Eastern Region National Forests: 1930-1980

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OGDEN, UT.

## FRONT COVER PHOTOS (FROM TOP RIGHT COUNTERCLOCKWISE)

*Early tank truck used in the East. Water was pumped from a stream and then taken to treatment site to mix with chemical.*

*Chemical spraying application with hand sprayer to control white pine weevil on Norway spruce in the Allegheny National Forest.*

*The Bell 47 helicopter used in forest spraying. Helicopters may be the most used aircraft for insect suppression in the future.*

*(CENTER) European pine sawfly colony on Scotch pine.*

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# INSECT SUPPRESSION IN EASTERN REGION NATIONAL FORESTS: 1930-1980

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## OVERVIEW

> Next to the earth itself the forest is the most useful servant of man. Not only does it sustain and regulate the streams, moderate the winds, and beautify the land, but it also supplies wood, the most widely used of all materials. Its uses are numberless, and the demands which are made upon it by mankind are numberless also. It is essential to the well-being of mankind that these demands should be met. They must be met steadily, fully, and at the right time if the forest is to give its best service (Pinchot 1905).

Suppressing insect populations and preventing damage by them are integral parts of forest protection and management. We report here a history of the use of various insecticides and the effectiveness of these insecticides against a number of insects in the natural timber stands and plantations of the Eastern Region national forests. Also included are examples of silvicultural and cultural control practices.

This report documents the insect species needing treatment, the various treatments used, the suppression results obtained, and the national forests involved. We gleaned the information from numerous memos, letters, worksheets, maps, reports, and other documents in the files of the National Archives, Regional Record Centers, and a number of Regional offices. The documents recovered span more than 50 years and although some of the information we had hoped to find was unobtainable, the story is reasonably unbroken and accurate. A few "old timers," who lived part of the early history, reviewed and "corrected" early versions of the report and supplemented missing information from recall.

## The Eastern Region and Overall Insecticide Use

The Eastern Region (Region 9, R-9) as it exists today was organized on March 1, 1966, when the former Region 7 (R-7) was abolished. Most of the States in the former Eastern Region (R-7) were incorporated into the North Central Region (R-9) and the Region was renamed (fig. 1). The remainder of the R-7 States were incorporated into the Southern Region (Region 8). To search for records most efficiently, we needed to be aware of our Region's development and various shifts in headquarters' locations. Future Region 9 researchers will need this information also. For that reason, a more detailed history of the development of the Eastern Region is provided in appendix I.

The Eastern Region currently comprises 20 States and is bounded by Maine and Maryland on the East Coast and Minnesota and Missouri in the Midwest (fig. 1). Geographic subregions of Region 9 are the Lake States, Midlands, Northern Appalachia, and New England. The Forest Service administers more

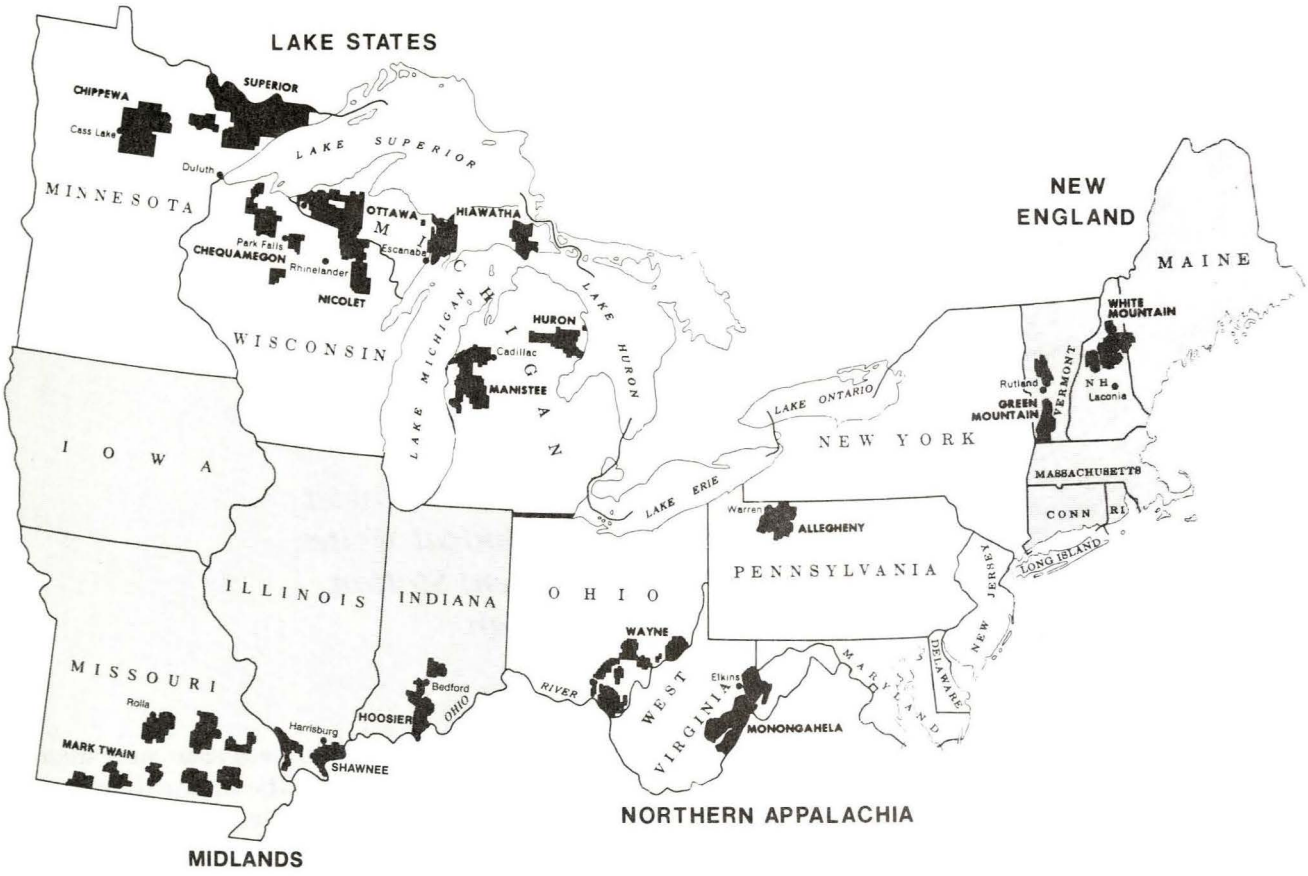



Figure 1.—*Eastern Region (Region 9) national forests by subregions, 1966-1980. Cities named are Forest Supervisors' headquarters.*

than 11 million acres in the Region's 16 forests (table 1). The remaining 10 million acres of land within the forest boundaries are owned by private individuals, industry, and State or local governments. Although acreages discussed in this history may once have been located in another forest or under another name, we have included them with the national forest in which they are now located. (See appendix I for acquisition details.)

During the half century covered by this history, if each of the 390,000 insecticide-treated acres had received only one application, then about 3.4 percent of Federal land would have received treatment (table 1). However, during the 50 years of this study, a number of acres included on table 1 were treated more than once, so the acres shown here (and thus the percentages) are higher than the actual Eastern Region national forest acres treated.

Of the four geographic subregions, the national forests in the Lake States have received the most attention during the period studied. About 367,000 Lake States' acres were treated with insecticides to suppress specific pests, and 9,400 acres received experimental insecticide treatments. Chemicals were applied on about 5.4 percent of the 7 million Lake States acres. Over the same period, 0.4 of the Midlands, <0.1 of the Northern Appalachian, and 0.5 percent of the New England national forest acres received suppression and/or experimental treatment, but lack of some documents from what was once Region 7 prevents exact figures of some acreages.

## Insecticide Use

Five types of insecticides—inorganic compounds, botanicals, chlorinated hydrocarbons, organophosphates, and carbamates—were applied to Eastern Region national forests in the 50 years of this study (table 2). (As in table 1, acres shown include those treated more than once during the 50 years of this study.) In addition, unspecified insecticides in unknown quantities were applied on about 30,000 acres from 1937 to 1951 (from 1937 to 1942 most

Table 1.—*Eastern Region national forest acreages by subregions and acres treated with insecticides for suppression and experimental testing from 1930—1980*

| National forest[a] | Forest acreage[b] | Acres treated for[c] | | Total | Percent acres treated[c] |
|---|---|---|---|---|---|
| | | Suppression | Testing | | |
| | | **LAKE STATES** | | | |
| Chequamegon | 844,515 | 47,964+ | 1,000 | 48,964+ | 5.8+ |
| Chippewa | 660,959 | 27,614+ | 224 | 27,838+ | 4.2+ |
| Hiawatha | 880,722 | 46,835 | 15 | 46,850 | 5.3 |
| Huron | 414,022 | 10,433+ | 347 | 10,780+ | 2.6+ |
| Manistee | 506,533 | 80,997+ | 4,530+ | 85,527+ | 16.9+ |
| Nicolet | 654,025 | 56,020+ | 2,425 | 58,445+ | 8.9+ |
| Ottawa | 924,537 | 12,050 | 312 | 12,362 | 1.3 |
| Superior | 2,045,567 | 84,958 | 570+ | 85,528+ | 4.2+ |
| Subtotal | 6,930,880 | 366,871+ | 9,423+ | 376,294+ | 5.4+ |
| | | **MIDLANDS** | | | |
| Hoosier | 185,127 | 12 | 0 | 12 | <0.1 |
| Mark Twain | 1,447,849 | 268+ | 0 | 268+ | <0.1+ |
| Shawnee | 252,810 | 6,553+ | 951+ | 7,504+ | 3.0+ |
| Subtotal | 1,885,786 | 6,833+ | 951+ | 7,784+ | 0.4+ |
| | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 508,674 | 262+ | 385 | 647+ | 0.1+ |
| Monongahela | 842,106 | 25 | 0 | 25 | <0.1+ |
| Wayne | 174,641 | 215+ | 0 | 215+ | 0.1+ |
| Subtotal | 1,525,421 | 502+ | 385 | 887+ | <0.1+ |
| | | **NEW ENGLAND** | | | |
| Green Mountain | 279,374 | 4,719 | 0 | 4,719 | 1.7 |
| White Mountain | 728,092 | 437 | 0 | 437 | <0.1 |
| Subtotal | 1,007,466 | 5,156 | 0 | 5,156 | 0.5 |
| Regional total | 11,349,553 | 379,362+ | 10,759+ | 390,121+ | 3.4+ |

[a]Names given are current names. Name changes and/or combining of Forests sometimes occurred after initial establishment (see appendix I).

[b]Forest acreages are as of September 30, 1980 (USDA 1981).

[c]Plus sign (+) represents additional incompletely documented acreage treated.

acres were probably sprayed with the inorganic compounds lead arsenate and/or sodium arsenate; from 1945 to 1951 the unspecified insecticide was probably DDT).

Inorganic compounds were used mainly in the 1930's and early 1940's; lead and sodium arsenate were applied on the most acres. Such compounds were subsequently replaced in the mid-1940's by the less expensive and generally more effective chlorinated hydrocarbons.

Botanicals are derived from plant parts containing natural insecticides. The only use of a true botanical, nicotine sulphate, was in 1939. Resmethrin,[1] a synthetic reproduction of a botanical insecticide, was used in an experiment in 1973.

[1]*Mention of trade names does not constitute endorsement of the product by the USDA Forest Service.*

Chlorinated hydrocarbons, which came on the market at the end of World War II, generally replaced the inorganic compounds and early botanicals in forest insect suppression. DDT was the most widely used of this group: more than 265,000 pounds were used on more than 279,000 acres from 1945 to 1964. It was inexpensive, easy to handle, and had many desirable insecticidal properties; however, its use in the national forests was curtailed in the 1960's when undesirable side effects became apparent. Because DDT was effective against many species of insects, it was the standard against which the effectiveness of newer insecticides was measured. In 1964, the last year of its application, DDT was used only for such comparisons.

Organophosphates and carbamates, recent additions to forest spray programs, replaced the chlorinated hydrocarbons in the late 1960's. Although

Table 2.—*Insecticides and amounts applied to acreages of Eastern Regional national forests, 1930-1980*

| Insecticide | Years applied[a] | Amount used (lbs)[b] | Acres treated[b] |
|---|---|---|---|
| | **INORGANIC COMPOUNDS** | | |
| Lead arsenate | 1934-1958 | 5,706+ | 31,588+[c] |
| Calcium arsenate | 1934 | — | 1 |
| Sodium arsenate | 1936-1939 | — | 18,693 |
| Copper sulphate | 1937 | — | 4,719 |
| Arsenicals (unidentified) | 1938 | — | 140 |
| Sodium fluosilicate | 1948 | — | 415 |
| Ammonium sulphate | 1949 | — | 30 |
| Lime sulphur | 1954 | — | 28 |
| | **BOTANICALS** | | |
| Nicotine sulphate | 1939 | — | 830[c] |
| Resmethrin | 1973 | 1 | 30 |
| | **CHLORINATED HYDROCARBONS** | | |
| DDT | 1945-1964 | 265,101+ | 279,360+ |
| Chlordane | 1949 | 195 | 1,298 |
| Lindane | 1958-1966 | 57+ | 116+ |
| Aldrin | 1960-1967 | 1,577+ | 12,590 |
| Orthodichlorobenzene | 1960 | — | 12 |
| Benzene hexachloride | 1965-1967 | 25+ | 72+ |
| | **ORGANOPHOSPHATES** | | |
| Phorate | 1959 | 40 | 20 |
| Malathion | 1959-1976 | 6,513+ | 7,878+ |
| Naled | 1960 | — | 14 |
| Dimethoate | 1964 | 8 | 15 |
| | **CARBAMATES** | | |
| Mexacarbate | 1964-1973 | 135 | 545 |
| Aminocarb | 1968 | 75 | 500 |
| Carbaryl | 1966-1974 | 997+ | 1,082+ |
| | **UNSPECIFIED** | | |
| Unspecified | 1937-1951 | — | 30,145+ |
| | | Regional total | 390,121+ |

[a]Insecticide was not necessarily used every year during multiple-year periods.

[b]Plus sign (+) represents additional, incompletely documented acreage treated. Dash (—) indicates no data available; source documents were incomplete.

[c]Jack pine sawfly was treated on portions of 300 Manistee acres either with lead arsenate or nicotine sulphate alone or an unspecified mixture of them. In this table, we show that 150 acres were treated with each chemical.

organophosphates and carbamates are generally more expensive than the insecticides used earlier, they control pests through lower dosages.

Figure 2 (centerfold) shows by year the number of acres receiving chemical treatment in the Eastern Region national forests from 1930 to 1980. DDT was clearly the most used insecticide, particularly in 1962 when 104,300 pounds were applied. Arsenic compounds, the second most used insecticides, were mainly applied in the late 1930's. Next most used was aldrin, a chlorinated hydrocarbon like DDT; it was applied from 1960 to 1967. Malathion was sprayed on the fourth largest number of acres from 1959 to 1976. Finally, we have combined all other insecticides, including those unspecified in various documents, into the "Other" category to complete the pictorial record shown in figure 2.

The number and size of insect suppression projects diminished substantially in the final decade of this history. From 1970 to 1980, about 1,300 acres in five forests received chemical treatments, 31 percent of which was experimental. In 1962 alone, the year when the most insecticides were applied, suppression projects or experiments on nearly 109,000 acres in nine national forests were directed against eight insect species. The acreage involving DDT represented 1.5 percent of the Federal forest land within the nine forests and 1.0 percent of the total Federal acreages in the Region.

## Twenty-seven Target Insects

Beginning in 1934, 27 species of insects were treated with insecticides on more than 396,000 acres of Eastern Region national forests (table 3). (Total acres treated here are not actual because simultaneous treatments of insects such as the Saratoga spittlebug and the redheaded pine sawfly are reported twice.) Seventeen defoliator species were the most frequently targeted; nearly 281,000 acres were treated for defoliators during the 50 years. Treatments were also directed against two species of sap-sucking insects on more than 96,000 acres, one root feeder on about 13,000 acres, and four bud and twig borers on more than 1,600 acres. While three species of bark beetles were sprayed on more than 4,800 acres, the spruce beetle was the principal target on more than 2,000 trees throughout a 4,000-acre area. Twelve of the 27 targeted species necessitated suppression treatments on more than 1,000 acres.

In natural stands the treatments were mainly against spruce budworm and jack pine budworm—both defoliators. In plantations, the treatments mainly involved four species: Saratoga spittlebug, redheaded pine sawfly, grasshoppers, and white grubs.

Although tree planting was begun on some national forests in 1911, less than 1,000 acres were planted per year. With the advent of the Civilian Conservation Corps (CCC) and other programs in the 1930's, planting increased considerably, especially in the Lake States. Pests of young plantations soon became troublesome, and suppression was necessary against sawflies starting in 1934, grasshoppers in 1936, and the Saratoga spittlebug in 1945. White grubs began causing much concern in 1929, but were not treated with insecticide until 1960, other than a small experimental treatment with lead and calcium arsenates in 1934.

Throughout the 50 years of this history, the Saratoga spittlebug received the most attention (in six Lake States national forests, appendix II, p. 44); DDT was used exclusively from 1945 until 1964. When DDT use was curtailed, malathion was substituted in all but one of the forests. Effectiveness of insecticidal treatments against the Saratoga spittlebug ranged from 0 percent (in 1945 when 66 acres were experimentally treated with DDT at the rate of 0.25 lbs/acre) to several treatments judged 100 percent using either DDT or malathion.

Spruce budworm was the next most frequently targeted insect; suppression attempts against this insect took place in the Superior National Forest

*Authors Fowler and Wilson (pest management and research, respectively) examine redheaded pine sawfly damage on red pine in the Manistee National Forest during a 1970 impact study.*

only. In eight applications from 1957 to 1963, aircraft sprayed an average of less than 1 pound of DDT/acre on about 85,000 acres (appendix II, p. 46). The largest single suppression project in the Region occurred in 1962 against the spruce budworm; more than 56,000 acres on 25 separate parcels of land were treated (2.8 percent of the acreage in the Superior National Forest). Treatments using both 0.5 and 1 lb/acre were considered to be 97 percent effective.

Suppression projects on the redheaded pine sawfly covered more than 64,000 acres in 11 national forests (appendix II, p. 47). In 1939, lead arsenate and nicotine sulphate were used in the Manistee to treat the redheaded and jack pine sawflies simultaneously. In the Nicolet in 1948 and 1949, the redheaded pine sawfly and the Saratoga spittlebug were treated simultaneously with DDT. Beginning in 1960, malathion was applied by aircraft, hydraulic sprayer, mistblower, and hand sprayer; the heaviest application rate used was 2 lbs/acre on 200 acres in the Manistee National Forest. Unfortunately, results of these suppression projects were not always available.

The jack pine budworm was treated on six Lake States forests (appendix II, p. 50). DDT again was the principal insecticide used both experimentally and for suppression, generally at a rate of 1 lb/acre; effectiveness ranged from 78 to 98 percent. The highest use was in 1962 when nearly 36,700 acres were aerially treated on the Chippewa and the Hiawatha.

Table 3.—*Target insects and years and acreages treated with insecticides in Eastern Region national forests, 1930-1980*

| Target insect[a] | | Years treated | Acres treated[b] |
|---|---|---|---|
| | **DEFOLIATORS** | | |
| **Spruce budworm** | *Choristoneura fumiferana* (Clemens) | 1957-60, 1962-63 | 84,815 |
| **Redheaded pine sawfly** | *Neodiprion lecontei* (Fitch) | 1934-36, 1938-41, 1945-51, 1953, 1957-60, 1966, 1969-70 | 64,226+ |
| **Jack pine budworm** | *Choristoneura pinus* Freeman | 1939, 1950-51, 1957, 1959-62, 1964, 1966, 1968 | 61,392+ |
| **Grasshoppers** | *Melanoplus* spp. | 1936-42, 1948-49 | 50,706+ |
| **Pine tussock moth** | *Dasychira pinicola* (Dyar) | 1962 | 8,735 |
| **Jack pine sawfly** | *Neodiprion pratti banksianae* Rohwer | 1939 | 5,240 |
| **Forest tent caterpillar** | *Malacosoma disstria* Hübner | 1936-38, 1951-52 | 2,132 |
| **Gypsy moth** | *Lymantria dispar* (Linnaeus) | 1954, 1970, 1972, 1974 | 1,237 |
| **Loblolly pine sawfly** | *Neodiprion taedae linearis* Ross | 1957, 1965 | 1,135+ |
| **Larch sawfly** | *Pristiphora erichsonii* (Hartig) | 1940-41, 1948-50, 1959, 1965, 1967 | 497+ |
| **Cherry scallopshell moth** | *Hydria prunivora* Ferguson | 1974 | 225 |
| **Walkingstick** | *Diapheromera femorata* (Say) | 1950 | 210 |
| **Redhumped oakworm** | *Symmerista canicosta* Franclemont | 1973 | 120 |
| **Yellowheaded spruce sawfly** | *Pikonema alaskensis* (Rohwer) | 1968 | 61 |
| **Virginia pine sawfly** | *Neodiprion pratti pratti* (Dyar) | 1961-64 | 29 |
| **European pine sawfly** | *Neodiprion sertifer* (Geoffroy) | 1950, 1966 | 12+ |
| **Fall cankerworm** | *Alsophila pometaria* (Harris) | 1966 | 0+ |
| | | | 280,772+ |
| | **SAPSUCKERS** | | |
| **Saratoga spittlebug** | *Aphrophora saratogensis* (Fitch) | 1945-69, 1976 | 96,166 |
| **Pine tortoise scale** | *Toumeyella parvicornis* (Cockerell) | 1954 | 53 |
| | | | 96,219 |
| | **ROOT FEEDERS** | | |
| **White grubs** | *Phyllophaga* spp. | 1934, 1960-67 | 12,634 |
| | | | 12,634 |
| | **BARK BEETLES** | | |
| **Spruce beetle** | *Dendroctonus rufipennis* (Kirby) | 1937 | 4,719 |
| **Black turpentine beetle** | *Dendroctonus terebrans* (Olivier) | 1960, 1965, 1967 | 84+ |
| **Red turpentine beetle** | *Dendroctonus valens* LeConte | 1966 | 20 |
| | | | 4,823 |
| | **BUD AND TWIG BORERS** | | |
| **European pine shoot moth** | *Rhyacionia buoliana* (Denis and Schiffermüller) | 1951-52, 1957-60, 1962 | 946 |
| **White pine weevil** | *Pissodes strobi* (Peck) | 1950-51, 1958-59, 1962-63 | 686+ |
| **Pitch pine tip moth** | *Rhyacionia rigidana* (Fernald) | 1951 | 4 |
| **Nantucket pine tip moth** | *Rhyacionia frustrana* (Comstock) | 1946-49 | 2+ |
| | | | 1,638+ |
| | | | Regional total 396,086+[c] |

[a]Most common and scientific names used are those approved by the Entomological Society of America (Werner 1982).

[b]Plus sign (+) indicates additional treated acreages incompletely documented.

[c]The Regional total on this table is higher than Regional totals on tables 1 and 2 because this total reflects the simultaneous treatment of two insects.

Suppression and experimental pesticide applications were also used against 23 other insects (appendix II, p. 51). The insects are listed in appendix II, p. 51 in descending order of the land area treated from 1930 to 1980 and range from grasshoppers (more than 50,000 acres treated mainly with inorganic compounds) to the fall cankerworm (0+ acres treated with the carbamate carbaryl). Results were not available for a number of the treatments listed here.

The next section of this history will examine in detail the early years of insect suppression and experimentation in the Eastern Region.

## HISTORY OF INSECT SUPPRESSION

### In the Beginning . . .

> The forest is threatened by many enemies, of which fire and reckless lumbering are the worst. In the United States sheep grazing and wind come next. Cattle and horses do much less damage than sheep, and snow break is less costly than windfall. Landslides, floods, insects, and fungi are sometimes very harmful.
>
> . . . . . .
>
> Insects are constantly injuring the forest, just as year by year they bring loss to the farm. Occasionally their ravages attain enormous proportions. Thus a worm, which afterwards develops into a sawfly, has since 1882 killed nearly every full-grown Larch in the Adirondacks by eating away the leaves. Even the small and vigorous Larches do not escape altogether from these attacks. Conifers, such as the Larch and Spruce, are much more likely to suffer from the attacks of insects than broadleaf trees. About the year 1876 small bark beetles began to kill the mature Spruce trees in the Adirondacks, and ten years later, when the worst of the attack was past, the forest was practically deprived of all its largest Spruces. This pest is still at work in northern New Hampshire and in Maine (Pinchot 1903).

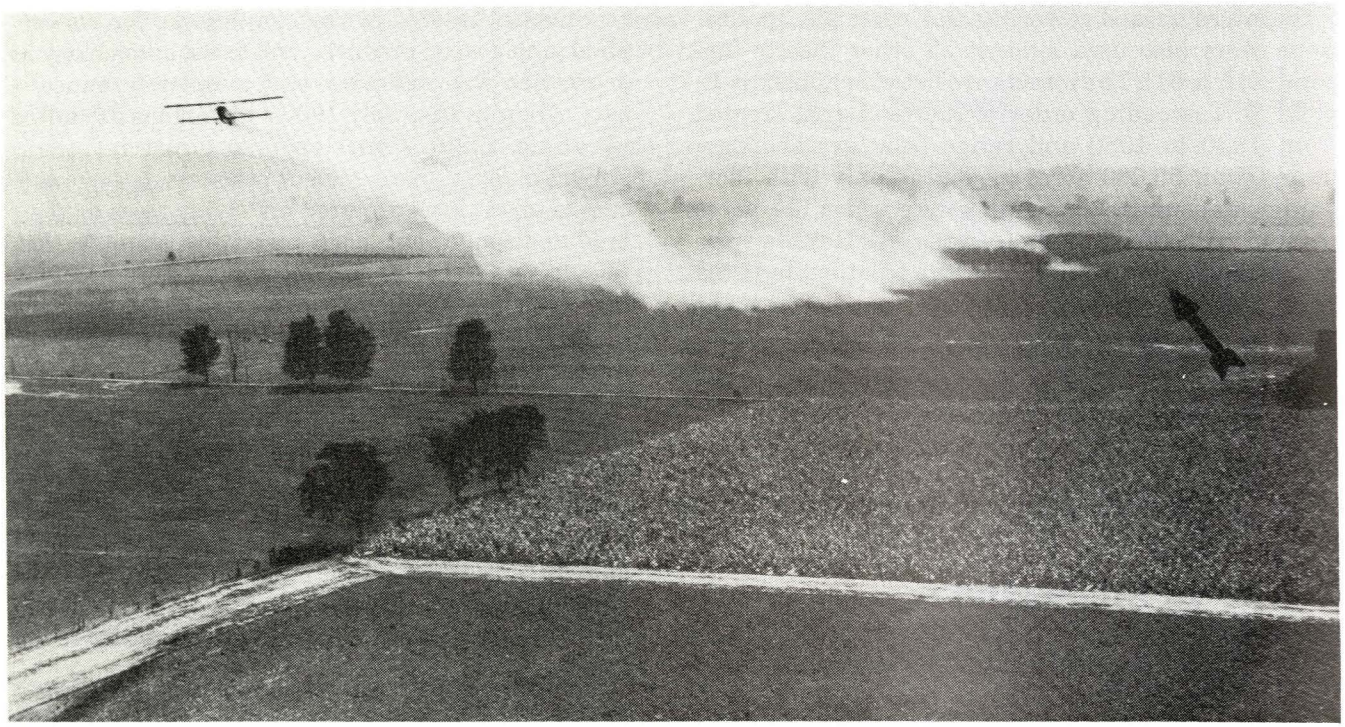
Before 1900, entomologists thought of forest insects in North America mostly as pests of shade and ornamental trees. Our vast continental forests supplied ample wood products, and forest entomology as a practice was unknown and completely unnecessary. Then in the early 1900's the emphasis shifted (Graham 1929). Conscientious foresters, newly skilled in forest management practices, became concerned about insect-injured and dying trees on their land and sought out forest insect investigators. Entomologists, who for the most part were studying insects as scientific curiosities, responded and soon began studying the biologies of forest insects to learn how to control them.

The Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine (BE&PQ) was established in 1902 to act ". . . as the clearing house for advice on when and where control measures should be undertaken on the national forests . . . and [maintain] a technical service for examining reported outbreaks and for giving advice on the application of control" (Gill and Dowling 1943).

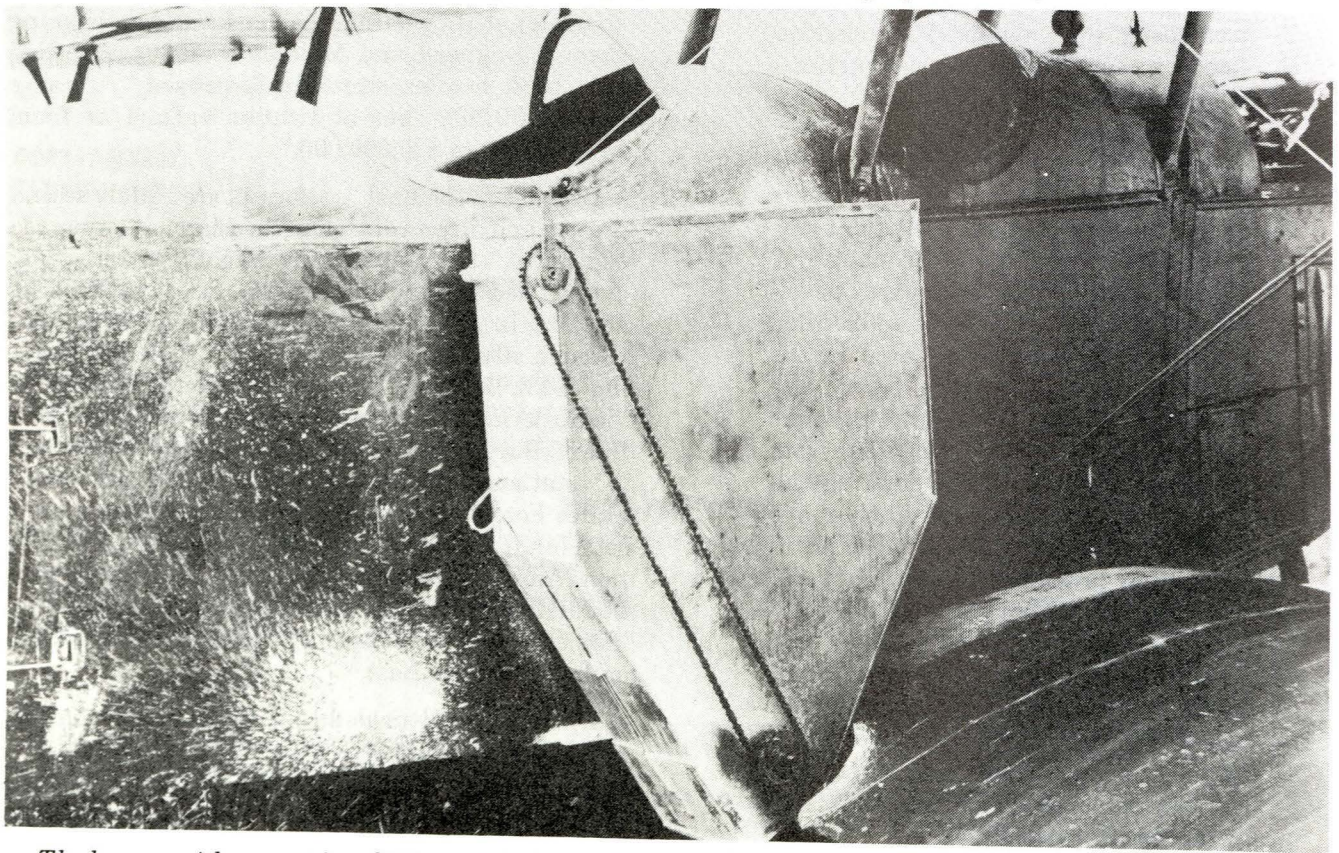
For years, the Bureau was mainly concerned with bark beetle (*Dendroctonus* spp.) control projects starting in the West in 1906 and in the South during 1914 and 1915. Control methods used were combinations of felling infested trees, bucking them into short lengths, peeling the bark, and/or burning them. Craighead and Middleton (1930) estimated that bark beetles annually destroyed ". . . over 6,000,000,000 feet of timber valued at from $15,000,000 to $20,000,000."

Because in the East ". . . forests are mainly second growth and direct control methods are, as a rule, too expensive," forest insect investigations were ". . . closely tied in with those of the forest experiment stations in an effort to prevent insect outbreaks through silvicultural practices . . ." (Gill and Dowling 1943). Because "cooperation with the Forest Service experiment stations [formed] another important line of [Bureau] activities," a few entomologists were ". . . stationed at, or in close touch with, . . . the Lake States Forest Experiment Station, St. Paul, Minnesota, [and] the Northeastern Forest Experiment Station, Amherst, Massachusetts . . ." (Craighead and Middleton 1930). These professionals assisted with insect surveys or followed up verbal reports of insect outbreaks in the East.

While silvicultural methods of insect control predominated in Eastern Region national forests before 1930, chemical control was also considered. "Shafer in 1915 published his pioneer work, 'How Contact Insecticides Kill,' . . . which did much to whet [entomologists'] appetites to learn more of the mechanisms of insecticide intoxication to insects . . ."



*Curtiss JN-6 used to treat catalpa sphinx in the world's first airplane dusting operation in 1921; in less than a minute, a total of six flights were made across the damaged area. (The arrow indicates the direction of the wind.) Photo by Captain A. W. Stevens, Courtesy of the National Geographic Society.*



*The hopper with a capacity of 100 pounds that carried and distributed a total of 175 pounds of lead arsenate powder on catalpa sphinx near Troy, Ohio. The hopper was attached to the airplane fuselage. Photo by J. S. Houser, Courtesy of the National Geographic Society.*

*Loading the Decatur Aircraft Company's biplane with the 200 to 300 pounds of calcium arsenate needed for each flight. Note the operator pouring the dust into the hopper while standing behind the prop blast. Photo by A. A. Granovsky. Courtesy of D. M. Benjamin, University of Wisconsin.*

(Telford 1967). Even though this book was mainly aimed at nonforestry uses of insecticides, foresters knew that chemicals with known insecticidal properties were potentially useful on forest pests too.

The "usual method of controlling leaf-eating insects affecting tall trees" in the early part of the century was "by the use of liquid poisons sprayed on the trees by means of engine-driven pumps, these outfits having reached their present development in the New England States in combating the gypsy and brown-tail moths and elm-leaf beetle" (Neillie and Houser 1922). However, in 1921, C. R. Neillie and J. S. Houser wanted to overcome some of the difficulties and expense of spraying tall trees, particularly those situated on very uneven terrain, and chose to experiment with "the airplane as a distributor of insecticides." On August 3, 1921, "a Curtiss JN-6 equipped with a hopper for carrying and liberating the poison powder" applied lead arsenate against the catalpa sphinx (*Ceratomia catalpae* Bvd.) on 6 acres at Troy, Ohio, at a rate of 29 lbs/acre. The dusting took 54 seconds, "thus establishing a world's record for speed in applying insecticides to forest areas," but "the outstanding feature of the application was the remarkable precision with which the poison could be placed at the point intended. . . ." Less than 1 percent of the caterpillers remained alive on the sprayed trees. The conclusion of Neillie and Houser (1922) about the success of the airplane dusting experiment was, "In the treatment of tall trees in park and forest areas the tremendous saving in time and labor in which its use results would seem to indicate that the method is wholly practicable."

Following the dusting in Ohio, "In 1922 the Bureau of Entomology initiated two separate series of experiments in this work; one at the Delta Laboratory, Tallulah, Louisiana, and the other at the Gipsy Moth Laboratory, Melrose Highlands, Massachusetts. The experiments at the Gipsy Moth Laboratory were not conclusive for the first 2 years" (Barnes and Potts 1927).

The next documented airplane dusting experiment in the Eastern Region was in June 1926 in Massachusetts—once again against the gypsy moth. The first application of lead arsenate at 40 lbs/acre on one 25-acre plot took 82 minutes to complete because of mechanical difficulties with the hopper. Three days after dusting, rain fell, so the plot was redusted 8 days after the first treatment. On the total of six plots dusted in this experiment, ". . . the treated plots showed much less defoliation than the untreated checks. . . ." Barnes and Potts (1927) concluded, "Airplane dusting is best adapted for the treatment of large forest areas and its results for the

season of 1926 encourage the hope that this method can be adapted for insect control in such territory."

The next month, a "large-scale" insecticidal control program was initiated against hemlock spanworm, (= hemlock looper, *Lambdina fiscellaria fiscellaria* (Guenée)), on State land in Wisconsin (Fracker and Granovsky 1927). Calcium arsenate was applied at the rate of 20 lbs/acre by airplane to 715 acres of the Peninsula State Park in Door County, Wisconsin. Although the treatment gave marginal control by present standards (60 to 95 percent insect mortality), the program continued to convince everyone involved that both chemicals and aircraft could be useful tools in the future.

## The Early Years

## (1930-1944)

By the 1930's, interest in insect control was increasing in the Eastern Region national forests. Nationwide funding had become available for insect and disease research through the McNary-McSweeny Act of 1928 (Knight and Heikkenen 1980). In 1930, when the Forest Service was 25 years old, several forest pests came under scrutiny by Lake States foresters. At the end of that year, E. W. Tinker, Regional Forester in Milwaukee, submitted to Robert Y. Stuart, the Forester[2] in Washington, an insect control report detailing infestation problems. (The 1930 report is the first regional annual report on insect control available in Eastern Region files.) The jack pine sawfly and engraver beetles, which had killed some jack and red pines, were the major concerns. Also, the jack pine budworm—incorrectly identified as the spruce budworm feeding on pine—caused noticeable defoliation to several jack pine stands. The infestations were not serious enough for control, and a response was not expected from Washington. F. C. Craighead, then Principal Entomologist for the BE&PQ in Washington, was alerted by Assistant Forester E. E. Carter to the report.[3] The white grub received attention in the 1930 annual planting report. In the Chippewa's Beal Nursery, "The greatest damage in the plantation was due to extreme drouth coupled with white grub activity" (Wales 1931).

In 1931, as field observations intensified, more problems were observed in the Lake States. All forest officers were ". . . urged to watch for signs of insect infestation in their respective districts, and to collect and forward samples for identification" (Tinker 1931). That summer the birch skeletonizer (*Bucculatrix canadensisella* Chambers) began an upsurge over thousands of acres in several forests from Minnesota to Michigan. Although more objectionable than damaging, it was especially troublesome to owners of lakeshore and summer homes. Tinker requested from Washington a feasible method of control that he could pass on to summer residents because the Forest Ranger closest to the problem had implied in his report to Tinker that no practical control was known for forest use. Forest Ranger Braudner (1931) had suggested that arsenical dusts or sprays might be used for limited areas around homes.

Of more concern was the injury to newly planted red pines by white grub in the Chippewa and Marquette (Hiawatha) Forests. These injuries, coupled with several successive years of drought, were killing trees. Tinker (1931) wrote, "If damage continues [in the Chippewa], it will probably be well to secure the assignment of an entomologist to study the question specifically." When it was noted that the white grub did not appear to attack natural jack pine reproduction in the Marquette Forest, an experiment was "started to determine whether natural reproduction cannot be secured . . ." to cut down on white grub problems. Foresters piled brush around jack pine trees and set it on fire to kill the trees and at the same time open the cones to scatter the seeds. To learn whether there was any advantage in soil preparation, foresters planned three experiments around the trees to be burned: disking, burning over, and leaving the area untouched (Wales 1932).

Also in 1931, the coarse-writing beetle (*Ips calligraphus* (Germ.)) killed two jack pine trees at the Norways Ranger Station, Raco, Michigan, and nearly 30 more trees died in a sale area nearby. Weakened by drought, the trees attracted the beetles. This episode instigated a control and preventive treatment in which "The trees at the Ranger Station were cut and burned before the insects emerged, so as to check a possibility of epidemic conditions . . ." (Tinker 1931). Although the white grub and coarse-writing beetle treatments were not spectacular control programs, they were appropriate and

[2]*Gifford Pinchot, the first Chief of the Forest Service, had requested that the title "Chief" be changed to "Forester" in 1898. The title Chief was readopted in 1935.*

[3]*Carter, E. E. Assistant Forester, Washington Office. Letter to the R-9 Regional Forester. December 6, 1930.*

timely, and showed a growing concern for insect problems.

By the next year, foresters had become keen observers; they accurately noted that sawfly, spruce budworm, and cone-insect populations were increasing, and the major problem pests from the year before were generally declining. At the Chippewa Nursery, the State Nursery Inspector spotted a pine scale on several large jack pines nearby. Insisting that there was a good chance of infesting the red pine seedlings in the nursery, he recommended that 30 heavily infested trees be cut and burned (Tinker 1932). Effective chemical controls were unknown and untested for the scale, so cultural means were once again marshalled for the job.

By mid-summer of 1932, field crews, now acutely aware of insect problems, were submitting specimens almost weekly for identification. Sometimes specimens were sent to Washington, but more often they went to such experts as the State Entomologist of Minnesota and foresters of the Lake States Forest Experiment Station. In addition, insect specimens routinely went to qualified entomologists at the University of Minnesota, the University of Wisconsin, Michigan State College (now Michigan State University), and the University of Michigan. Samuel A. Graham, Professor of Economic Zoology at the latter institution, participated in the study of forest pest problems of the entire Region.

The election of Franklin D. Roosevelt in November 1932 was to make conservation of our forest resources one of the most important government programs before World War II. According to Steen (1976), in the time between Roosevelt's election and the inauguration, the President-elect ". . . considered combining land acquisition with relief for the unemployed. His staff prepared an $18 million proposal to purchase land east of the Mississippi River, with a like amount appropriated to pay for rehabilitation." Unemployment relief was to come through the Emergency Conservation Work Act (ECW) of 1933, which provided for the Civilian Conservation Corps (CCC). Roosevelt's purchase scheme was closely linked with the CCC because he ". . . wanted 'plenty of land' for the corps to rehabilitate" (Steen 1976). After appropriations of $45 million from 1933 to 1935, nearly 8 million acres were purchased and added to Eastern national forests (Dana 1956). One of the largest projects undertaken by the Corps during its 9 years of existence was reforestation of Lake States forests by planting trees.

In 1932 and 1933, foresters became greatly concerned about insect problems in the newly established plantations. A report of the Region 9 Planting Board of Review noted:

> Forest Service planting has been in progress in the Lake States for nearly

*CCC crew from Mormon Creek Camp, Michigan, rehabilitating the Hiawatha National Forest by planting the single tree species red pine, 1939. Large acreages of single or closely related mixed species led to serious insect infestations.*

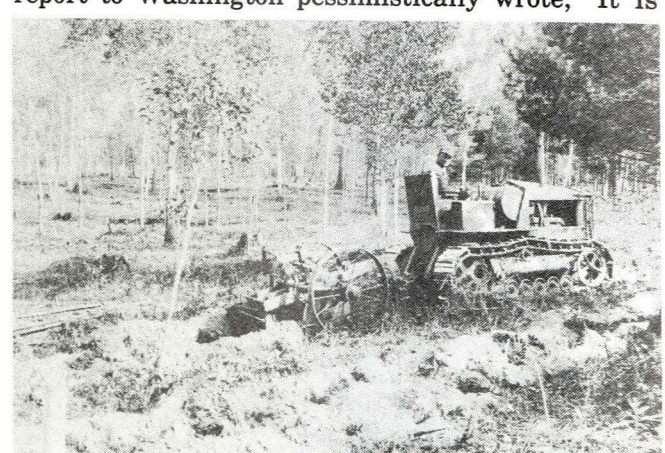
> 25 years. Yet the annual program never exceeded 1,000 acres until about 1926. Since that time it was gradually increased until the advent of the CCC when it received tremendous impetus.
>
> The earlier efforts resulted in several highly satisfactory plantations which appeared to justify an expanded program. During the last few years the percentage of successful plantations appears to have progressively declined, culminating with extremely heavy losses during the past year (Shirley *et al*. 1934).

As 1932 ended, plans were being made to hire an entomologist who would survey the Lake States forests to determine insect conditions and recommend pest control. As a result, Dr. Graham was approached and hired for the summer of 1933 to give "technical assistance" under the auspices of the ECW program (Tinker 1933).

Graham spent much of that summer on the Huron, Superior, and Chippewa National Forests, and, as one might expect with expertise on board, several more insect problems were uncovered. While reporting his findings to the Forest Supervisors that fall, he recommended several immediate cultural treatments.[4] For example, he suggested stopping planting in openings where jack pine budworm was abundant and removing all wolf trees to curb the budworm.[5] The Huron Forest put these recommendations into their management plans for the years following. A weevil attacking the root collars of pine was killing 15- to 20-year-old Scotch pines on the Chippewa, and Graham recommended cutting the infested trees and grubbing out and burning the roots to reduce the trouble.[6] ECW camps on the Superior National Forest concentrated on the spruce budworm to place the forest in a thrifty growing condition. Graham had recommended cutting all balsam fir in release operations for budworm control.[7] This recommendation was readily accepted because most land managers had long considered balsam fir an inferior species to be discriminated against in managing timbered areas. Graham specified no planting in open, sodded fields to prevent losses from the seedling-killing white grub. He suggested using wide, deep furrowing when planting (instead of the narrow furrowing typical of the standard horse-drawn plows).[4] Thus, the necessary expertise had finally come to solve forest insect problems on the national forests—at least in the Lake States.

Most of the cultural practices suggested by Graham were implemented in 1934 and 1935 (Tinker 1935). Efforts concentrated heavily on white grubs, and CCC labor was used for the grub surveys. As a result, some proposed sites were eliminated from the planting program, and seedlings on other sites were planted closer together to allow for the losses. The BE&PQ was "urged to carry forward the white grub studies now under way and to undertake other insect studies within or near the plantations from time to time" (Shirley *et al*. 1934).

In 1934, chemical control was used and documented on Eastern Region national forest land for the first time (Fowler 1973b). In the Manistee National Forest, lead arsenate was tried against the redheaded pine sawfly—an insect that normally can be controlled easily with almost any chemical. A small chemical test (using lead arsenate) was also tried against white grubs in newly established plantations in the Chippewa National Forest (Nagel 1936). Results of the latter were unsatisfactory, however, and the next year Tinker (1935) in his annual report to Washington pessimistically wrote, "It is



*Tractor and plow making wide, deep furrows in an aspen conversion area to prevent losses from seedling-killing white grub in the Chippewa National Forest, 1934. Before the conifer seedlings were planted, their roots were dipped into a lead arsenate suspension. Photo by A. A. Granovsky.*

[4]*Graham, S. A. Professor of Economic Zoology, University of Michigan. Memorandum concerning entomological observations on the Huron: August 29, 1933, to September 16, 1933, inclusive. September 30, 1933.*

[5]*Graham, S. A. Memorandum relative to spruce budworm control on the Huron Forest. July 30, 1933.*

[6]*Graham, S. A. Insect situation on the Chippewa Forest. August 14, 1933.*

[7]*Graham, S. A. Insect situation on the Superior Forest. August 28, 1933.*

*Truck and hydraulic sprayer used in forest tent caterpillar control in the Superior National Forest in June 1936.*

apparent that the possibility of finding a satisfactory chemical for use in grub control . . . is rather remote."

The redheaded pine sawfly continued to get attention the next year. This pest had started injuring trees in 1930; by 1935 it was abundant and was devastating pine in the Lake States. Regional Forester Tinker (1935) suggested that hand dusters or hand sprayers would be useful in chemical control of the sawfly because the trees affected were small. He noted, "Spraying was attempted on a small scale on the Huron this year, but the work was not started until the larvae were nearly mature, with the result that it was not very satisfactory." Undaunted, he added, "It seems highly desirable that control work be done next year, both on the Manistee and the Huron, and plans are being made to do so."

Spray-consciousness broadened in 1935. Chemicals were considered for other insects—including the forest tent caterpillar, which by then had defoliated more than one-half million acres of aspen and birch. This nuisance was discouraging tourists and threatening the recreational economy. Resort owners demanded help in controlling this pest. Surveys indicated that caterpillars would increase tremendously the next year, so plans were made to treat a total of 4,000 acres in 80 resorts. In the Region 9 annual report, Tinker (1935) wrote that hydraulic sprayers mounted on trucks would be efficient for spraying trees with lead arsenate. In addition, he noted that dusting with lead arsenate by an autogyro had been suggested. Tinker stated that while the autogyro would be faster and cheaper than power spraying, it was less reliable, although it had ". . . the advantage of being usable in places inaccessible by trucks." His annual report stipulated:

*Spraying aspen for forest tent caterpillar in 1936. (Hose is attached to hydraulic sprayer in other photo.)*

> Airplane dusting work usually requires about 20 lbs. of poison per acre [by air], but somewhat less should be required in spraying [i.e., by power sprayers on a truck]. At the rate of 20 lbs. per acre we will need about 80,000 lbs. of lead arsenate, which at $200 per ton will cost about $8,000.

Tinker budgeted an extra $455 to purchase 650 gallons of fish-oil sticker to be added to the spray mixture.

Another first occurred in 1935—Forest Service personnel targeted an integrated approach to control the larch sawfly. The infestation was located in a "swamp" near Deer River just east of the Chippewa National Forest. According to Tinker (1935), the outbreak

> . . . has been effectively checked. This has been accomplished by the liberation of parasites, flooding of the swamp, the application of lead arsenate dust,

> and by the aid of several very severe rainstorms which occurred during the time the larvae were feeding.

(This lead arsenate application is not included in appendix II because the work did not occur on national forest land.) He later noted that the BE&PQ had arranged to try rearing parasites from cocoons for future control programs.

Tinker's 1935 report further showed that concern for insect problems had spread to the Midlands Subregion because of "a rather severe infestation of the Nantucket pine tip moth" in the Shawnee National Forest. Control by removing the infested tips was tried and found somewhat successful. Additionally, bark beetles (*Ips* and *Dendroctonus* spp.) were controlled on the Clark National Forest (now part of the Mark Twain) by cutting and burning infested trees (Gilmore 1935).

One of the reasons for so many insect infestations during this time was the size of the planting program. According to the R-9 annual planting report, "The enlargement of the older forests and the addition of several new purchase units in the Region during the past three years has raised the size of the annual planting program to 150,000 acres." The planting "Master Plan" called for the reforestation of 3,000,000 denuded acres in the 15 years following (Grapp 1936).

The year 1936 brought the first large-scale control operation in the Region. Three insects were treated with arsenicals, but the insects of the year were various species of grasshoppers (Orr 1936). A severe drought on the Manistee nearly eliminated the grasshoppers' natural food supply, and in desperation they fed on pine seedlings. Millions of grasshoppers were killed when more than 18,000 acres were baited with poisoned bran, but not before the young plantations were severely damaged. Other acres were chemically treated for the forest tent caterpillar (in the Chippewa and Superior) and the redheaded pine sawfly (in the Hiawatha and Manistee). The results of the latter treatments brought a change in philosophy. Chemical control began to prove itself in the Lake States area, and cultural control started to take a "backseat."

During 1936, there was also a great deal of concern over ". . . an outbreak of the spruce barkbeetle on and near the Green Mountain National Forest in Vermont.[8] E. E. Carter, Chief, Division of Timber Management in the Washington Office (WO), recalled that early in the 20th century the ". . . barkbeetle did a very large amount of damage on some townships in western Maine."[8] Something had to be done soon to curb this pest.

In November of 1936, Region 7's Forester was informed by Carter that $1,500 Emergency Relief Administration (ERA) money ("Eradication" Project 5002) had been transferred from Region 1 to Region 7 to start a late spring control operation on the northern division of the Green Mountain Forest. This allotment was increased by $500 from the WO Insect Control Fund "for supplementary supervision, equipment, transportation, and other costs. . . ."[9] Carter suggested that Region 4's successful larval killing method be tried to reduce suppression costs per tree. According to Carter, their method was spraying thin-barked trees (lodgepole pine) "with oil and heating up the bark by fire to the point where insect larvae are killed." Because temperatures of at least 70° F seemed essential for oil penetration, F. C. Craighead, who was in charge of WO Forest Insect Investigations of the BE&PQ, noted that Vermont spring temperatures alone would not make this method feasible.[9]

Insect problems were becoming so obvious to Region 9 field personnel by 1937 that the Region's annual report read like the rogues' gallery (Watts 1937). More than 20 pests were listed on as many hosts from the Lake States, Midlands, and Northern Appalachia Subregions. Chemical control efforts were concentrated on grasshoppers, the forest tent caterpillar, and the larch sawfly. The white pine weevil, which had no known chemical control prescription, was treated by removing and destroying infested leaders.

The Green Mountain National Forest still had its insect problems, and ERA laborers and ECW enrollees scouted to locate bark beetle infestations between January and June of 1937. During this time, the Green Mountain experimented with Region 4's oil heating method against bark beetle larvae, but "due to the relative thickness of the spruce bark it was impossible to secure adequate control by this method and it was abandoned" (Varney 1937). Even though they weren't happy with their experiment, Green Mountain foresters suggested future experiments with "standing-burning" methods of control such as the use of heavier oil, a propane or gasoline torch, or a standard plumber's torch.

[8]*Carter, E. E. Chief, Division of Timber Management, WO. Letter to the R-7 Regional Forester. September 8, 1936.*

[9]*Carter, E. E. Letter to the R-7 Regional Forester. November 14, 1936.*

In June of 1937, Craighead wrote to J. E. Evenden in Idaho as follows:

> The Forest Service have a right nice barkbeetle outbreak on the Green Mountain National Forest in Vermont. This is a spruce area and there are approximately 5,000 trees infested. It was planned to handle it by timber sale but those "uncanny New Englanders" somehow or other got the idea that the trees will be a lot cheaper after they are dead and the Forest Service couldn't get any bids. Consequently they have the bug trees and the green trees still on their hands.[10]

He then asked for the "loan" of one of Evenden's experienced men starting July 1, 1937, because of plans to ". . . use the chemical method of treatment during the summer and other methods through the Fall and probably chemical sprays next Spring."[10] The plan was to use copper sulphate in 1937 and to try chemical sprays, principally orthodichlorobenzene and napthalene carried in fuel oils, in the spring of 1938. However, "between July 17 and August 16 [1937] some 260 infested trees were treated with copper sulphate," but ". . . this method did not prove satisfactory, due in part to the overlapping of generations and decadent condition of the trees. . . ."[11] According to the Green Mountain fiscal year (FY) 1938 report, 440 trees (probably including the 260 previously mentioned) were treated by copper sulphate injection on two widely separated areas during the 1937 summer period of sap flow. (A total of 36,420 Federal, State, and private acres were infested.) Concurrent with this chemical treatment, foresters peeled the bark of infested trees. "During late summer and fall, trees were cut and decked for winter burning" (Woodbury and Newman 1938). In Falls Brook, Vermont, where the chemical injections took place, a horse was used to skid 12-foot logs into larger decks for burning. While the Green Mountain report states, "Where practicable infested timber was salvaged," it also notes, "It is felt that burning is the only sure way of obtaining complete killing of all insects."

In addition, the Green Mountain had a European spruce sawfly infestation that year. R. C. Brown, Entomologist in Charge of the BE&PQ, suggested that ". . . no direct control measures such as spraying are feasible in forested areas because of the cost." He felt that the only practical method was the one used on September 17, when 90,000 European parasites, *Dahlbominus fuscipennis* (Zetterstedt), ". . . were liberated at three points within a radius of two miles of Lincoln Village."[12] Because of the increased importance of the sawfly, representatives of the Bureau arranged a conference with representatives from the Canadian Government on November 12. They decided ". . . to enlarge the work on propagating parasites in this country with the idea of increasing the number that may be available for colonization."[13]

On November 15, 1937, the Green Mountain tried a new method to get rid of the spruce beetle—this time experimenting with the explosive fuses Cordeau-Bickford and Primacord, manufactured by the Ensign-Bickford Company primarily for quarrying. Both enclosed TNT in a fabric cord. The fuses, which explode along their length almost instantaneously, were wrapped around both dead and infested green trees. All experiments proved unsatisfactory as reported by the manufacturer:

> Our product, Primacord, was not of sufficient strength to debark even the dead trees, the bark of which is generally very loose. Cordeau-Bickford wound spirally about a tree would remove the bark on dead trees for a distance of about 10 feet up from the ground, but higher on the tree where the bark is generally tight Cordeau would score thru the bark but would fail to peel it. Various methods of application of Cordeau were tried using varying distances between spirals and by running the Cordeau lines perpendicularly on all sides of the tree.[14]

The late 1930's and early 1940's brought shifts in personnel and emphasis. E. W. Tinker, Regional Forester, left Milwaukee to become Assistant Chief

[10]*Craighead, F. C. Entomologist in Charge, Forest Insect Investigations. Letter to J. E. Evendon. June 17, 1937.*

[11]*Schaffner, J. V., Jr. Memorandum for Mr. R. C. Brown. November 16, 1937.*

[12]*Brown, R. C. Entomologist in Charge, New Haven, Connecticut. Letter to Mr. Otto G. Koenig, Forest Supervisor, Green Mountain National Forest. September 22, 1937.*

[13]*LeCron, J. D. Assistant to the Secretary, Department of Agriculture, WO. Letter to C. Edward Behre, Secretary, Northeastern Forest Research Council. December 16, 1937.*

[14]*Brandon, J. K. Vice President, the Ensign-Bickford Company. Letter to R. M. Evans, R-7 Regional Forester. December 2, 1937.*

in Washington in 1936. Lyle F. Watts took on Tinker's former responsibilities. Similarly, L. W. Orr, one of the principal entomologists in Region 9, was transferred to the BE&PQ in Washington in 1938 and was replaced by H. J. MacAloney (Watts 1938). Foresters in Region 9 suggested that the Bureau research the jack pine budworm problem because no control method was suitable, but funds were lacking. In 1938, E. E. Carter wrote Regional Forester Watts that it was fortunate that Watts did not ask for an allotment from the limited insect contingency control fund held in Washington ". . . in view of the urgency of the demands on this fund for control work against barkbeetles in several of the western Regions."[15]

A devastating hurricane on September 21, 1938, blew down about 3-billion board feet of timber in New England and brought Congressional appropriations to the White Mountain National Forest in New Hampshire and Maine. The White Mountain received $500,000 for forest fire hazard reduction and Congress appropriated an additional ". . . $5,000,000 for forest-fire-hazard reduction work outside the national forests in New England" (Gill and Dowling 1943). Under the leadership of E. W. Tinker, two major activities were almost immediately undertaken—". . . the protection of the affected area from fire and the salvaging of the hurricane-damaged timber so that owners could recover some of the values that otherwise might be lost to them." Because much of the downed ". . . timber was pine, water storage was used whenever possible to eliminate damage from insects and disease" (Gill and Dowling 1943). (This is a method that Carolus Linnaeus [1707-1778] is said to have recommended in Sweden in the 18th century.)

While the Region 7 annual insect report (CY 1939) did not reflect these activities, it did show that no insect control project had been conducted that year; consequently the Region 7 report was confined to "Percent of Reduction Obtained" (Evans 1940). For example, a survey of the Boydon Brook area of the Green Mountain showed that the number of spruce beetle-infested trees per acre dropped from 80 in 1938 (before treatment) to less than 0.1 in 1939. Entomologists also checked the status of the bark beetle in the blown down spruce on both the White and Green Mountain Forests but found no threatening outbreaks (Evans 1940).

Pressure of research in 1939 and 1940 kept Bureau personnel from making regular visits to the national forests as they had done in previous years. In addition, the reduction in CCC crews because of the upswing of the Nation's economy nearly halted insect surveys. The Bureau therefore sent vials of alcohol to the districts so field personnel could send in specimens as they found them during their routine work (Price 1940).

*White pine trees as large as 3 feet in diameter damaged by the 1938 hurricane in New Hampshire. As many logs as possible were stored in ponds to prevent damage from insects and disease. Joseph Kaylor of the USDA Forest Service is standing on a fallen tree.*

*Hurricane-damaged 65-year-old managed spruce stand in the White Mountain National Forest 1938. No bark beetle outbreaks occurred in the downed spruce.*

[15]*Carter, E. E. Letter to L. F. Watts. November 15, 1938.*

The Region 9 annual insect report for 1940 pointed out that research was needed on problems developing from the large-scale planting program of the previous years. The older plantings were being injured by various sawflies and the white pine weevil; and they needed attention and protection (Price 1941). In his annual report for 1940, Regional Forester Price insisted, "This problem is considered so important that a request has been made to the Division of Forest Insects to carry out a study of plantation insects." Consequently, a grandiose study was proposed to devise ". . . silvicultural methods of preventing or limiting serious insect injury to the pine plantations of the Lake States."[16] Optimistically it included research on stand density, site variation, mixed plantings, and insect resistance. Plantation insect research began in 1941 on the Manistee with the Chittenden Nursery, Wellston, Michigan, as headquarters (Price 1942).

During CY 1940, Region 7 undertook two small, direct insect control jobs. One was the spraying of lead arsenate against the larch sawfly in a recreational area on the Allegheny—"Within two days after the treatment all of the insects were dead" (R-7 Forester 1941). The procedure on the second project began with sending CCC crews to scout the spruce beetle on 600 acres of the White Mountain. They located 396 infested trees which, early in 1941, were felled, "cut into short lengths, split, and piled over the stumps together with the brush and set afire" (R-7 Forester 1942).

Region 7's 1940 annual insect control report noted that Forest Service personnel had recognized natural control of an infestation in the vicinity of Peru, Vermont. Even though 15 to 20 percent of the trees in a red pine plantation had been defoliated by the redheaded pine sawfly, few of their cocoons could be found. Instead ". . . there was considerable evidence of their destruction by ground-inhabiting rodents" (R-7 Forester 1941).

Region 9 foresters were confident about their plantation insect research at the end of 1941. Their annual report stated, "Already it is reported that there is evidence that proper management methods will ensure a limitation of damage by [plantation] insects." The Regional Forester, however, feared that what had been gained might be lost as the country entered the war. Hence his insistence that "This plantation problem is given first priority rating in connection with national defense and should be carried on without interruption . . ." (Price 1942). The 1941 annual report marked the first discussion of the Saratoga spittlebug. Graham in 1956 recalled that in 1940 this insect was known only in museum collections, but 16 years later, it had become ". . . one of our most serious pests of sapling hard pines."

Assistant Forester Arthur O. Schafer (1942) reported in the annual planting report from the Hiawatha that spring planting was less than usual because of stock shortages. Although the fall season was characterized by an abundance of stock, there was an acute shortage of labor. "Local men are difficult to secure and the quality is very poor being largely those dropped by reduction of W.P.A." Nevertheless, a serious white pine weevil infestation in 485 acres of jack pine was controlled on the Hiawatha—". . . the infested terminals were removed by cutting with pocket knives and the tips burned" (Schafer 1942). That year marked the first recorded chemical treatment on the Wayne—186 acres were hand sprayed with lead arsenate for the redheaded pine sawfly (Fowler 1973a).

The most serious outbreak in Region 7 during 1941 was on the White Mountain where 4,000 acres of maple, beech, and birch were almost completely defoliated by the saddled prominent (*Heterocampa guttivitta* (Walker)). No control work was planned because when J. N. Schaffner of the BE&PQ examined two areas, he found that native predators had already destroyed 59 percent and 91 percent, respectively, of the pupae (R-7 Forester 1942).

During the war years there was a shortage of workers on the forests. Hundreds of thousands of CCC enrollees had answered the call to war in 1941. Congress, concluding that the purposes for which the CCC had been created had been served, eliminated the 9-year-old CCC program in June of 1942 (Guthrie 1943) and there was little concerted effort after that to survey for insects. Planting, although diminished, continued through the efforts of conscientious objectors and prisoners of war who lived in the abandoned CCC camps.

Research continued on plantation pests but concentrated on the Saratoga spittlebug, which had destroyed portions of numerous Region 9 plantings since 1940 (Ochsner 1943, 1944; Secrest 1945), and the larch sawfly, which had been active on the Allegheny since 1940 (R-7 Forester 1943). Control programs dwindled; when needed they were mostly cultural and implemented in cooperation with the Civilian Public Service Corps. The Corps' major control effort was cutting pine tortoise scale-infested

[16] *Anon. 1940 (?) Outline for a proposed ecological study of the pine plantations in the Lake States Region to determine silvicultural methods of preventing serious insect injury.*

trees and either leaving the cut material on the ground (the scales cannot live on the cut material) or burning it (Ochsner 1943, Wales 1945). Because of limited research information, curtailed surveillance, and shortage of materials, no chemical pesticides were applied on national forest lands in 1943 and 1944.

In 1944, Region 7 personnel realized that the spruce budworm was threatening spruce-fir stands on both the White and Green Mountain Forests. Entomologists knew that they had 5 to 10 years in which to prepare for possible epidemic outbreaks. In January of 1945, the Northeastern Forest Experiment Station and Regional Office personnel conducted training sessions for staff from both forests, and they helped draw up a plan of action. This plan contemplated

> . . . a survey to determine areas of high hazard, to direct timber-sale operations into such areas, and [formulated] a program for postwar TSI work in hazard reduction which cannot be handled through commercial sales (Mattoon 1945).

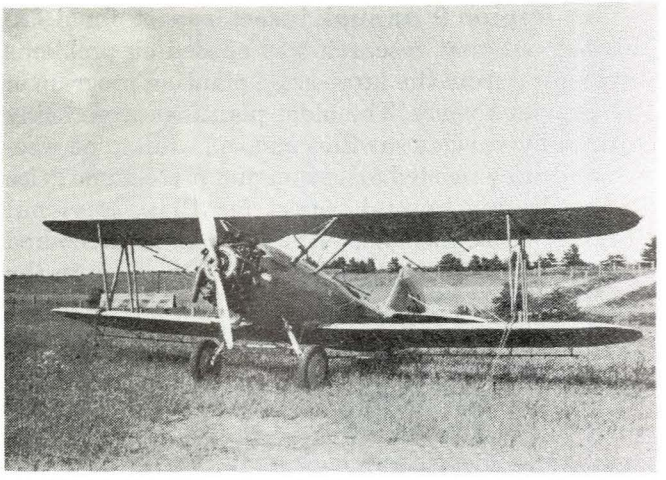
As the early years of chemical insect suppression were coming to a close, entomologists throughout the 20 Northeastern States had time to reflect on the past successes and failures from arsenical applications. By this time more than $3 million had been spent on the control of insect outbreaks in all Federal land, and a proportional amount of this had been used in the Eastern Region (Gill and Dowling 1943).

Besides doing limited research, the Division of Forest Insect Investigations became fully responsible for surveys during the war. With a shortage of personnel and added responsibilities, the Division did what it could, but like other short-handed agencies it tightned its belt and waited out the war.

## The DDT Era

## (1945-1964)

In the history of pesticide usage, the 20-year period after World War II aptly qualifies as its "Golden Age." Paul Müller's discovery of the insecticidal properties of DDT in 1939 and its subsequent success during the War led to its almost immediate testing against forest pests. Because arsenicals were harmful to man and not totally successful as control

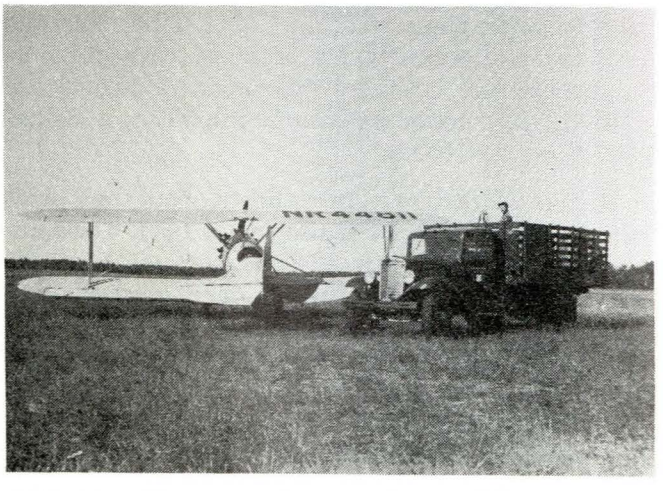


*N-3-N biplane equipped with a spray dispensing apparatus that was used in the first DDT control operation in Eastern Region national forests in July 1945. The Saratoga spittlebug was treated on 478 acres in the Nicolet National Forest. Photo by H. C. Secrest.*

agents, this new chemical was welcome. When the effectiveness of DDT was proven, it became almost the sole panacea for forest pest control.

The Saratoga spittlebug had been the greatest concern in Region 9 since 1940, and researchers concluded in the early 1940's that

> Control through the use of chemicals obviously would not be satisfactory. The adults are sucking insects and a contact insecticide would be necessary. They are extremely active, and any movement of the branches, such as



*A hand pump was used to transfer the DDT-oil mixture from the 55-gallon drums located on the bed of the truck to the spray tank of the N-3-N. Photo by H. C. Secrest.*

> would occur if a forcible spray was being projected against the trees, would be sufficient to cause them to move before the spray would cover them. The nature of the nymphal development, in masses of spittle usually beneath the litter surrounding the root collar of the sweet fern plants, precludes the use of contact sprays such as have been used successfully against the pine spittle bug (Secrest 1944).

After pesticide screening tests on the spittlebug in 1944 found DDT far superior to arsenicals and other chemicals (Anderson 1945, Secrest 1945), large-scale DDT tests followed in 1945 (Sump 1946, Secrest 1946). The first test occurred on July 13 and 14, 1945, when an N-3-N navy trainer plane sprayed DDT at 0.25 to 5 lbs/acre on 478 infested acres on the Nicolet. Shortly after the higher dosages succeeded in the tests, an additional 65 acres were treated on the Ottawa.

In the Nicolet study, the Fisheries and Wildlife Service assisted the BE&PQ's Division of Forest Insect Investigations in determining effects of DDT spraying on wildlife inhabiting the area. They were quoted in the 1945 annual insect report as observing that "no ill effects to any vertebrates were found in the area." The report added, however, that "In one pothole adjacent to the [sprayed] area . . . eight dead frogs were found and in an adjacent lake one small paralyzed garter snake and one dead frog were found." Subsequently, spraying at dosages of 2 lbs/acre or less was recommended. The report further noted the Region's plan to purchase enough DDT to spray 3,000 to 4,000 acres the next year (Sump 1946).

Such DDT tests did not go unnoticed by Forest Service officials in Washington. Only 3 months after the Wisconsin spraying, the Agency demonstrated how cautious it was about the new insecticide. In October of 1945, Lloyd W. Swift, Chief of the Forest Service's Division of Wildlife Management, stated the Forest Service's position on DDT at the 41st Annual Convention of the National Audubon Society. The position statement ". . . was part of a discussion on the use and effect of DDT by Federal, state, municipal, university, and conservation organization representatives. . . ."[17] Swift concluded the statement as follows:

> At this time the Forest Service is in no position to define the limits of usefulness of DDT in its work. We intend to consider fully both its advantages and disadvantages under the widely varying conditions which we have to meet. . . . Before its use is fully accepted, the Service would want to know what can be expected under a given set of conditions—what forms of beneficial life, insects, birds, amphibians, fishes, etc. would be endangered and to what extent (Swift 1945). (See appendix III for Swift's complete statement.)

While foresters were testing DDT in Wisconsin in 1945, silvicultural methods predominated in Region 7. There was such a demand for "National Forest stumpage" that stands vulnerable to spruce budworm attacks were reduced through commercial timber sales. As Forester Tabbutt wrote in the 1945 annual report:

> The personnel on both the Green and White Mountain National Forests have received training in identifying budworm attacks and are on the alert for new outbreaks of the insect. In the meantime, every reasonable effort will be devoted to placing our spruce-fir stands in the best silvicultural condition to resist attack and minimize damage (Tabbutt 1946).

Similar cultural controls were made against the spruce beetle, the bronze birch borer (*Agrilus anxius* Gory), and beech scale (*Cryptococcus fagisuga* (Lindinger)). In addition, Region 7 arranged to publish and distribute a pamphlet to advise private landowners in New Hampshire and neighboring States about the control of the latter two insects plus the spruce budworm.

Direct control measures initiated in New England forests in 1945 were expanded in 1946. Forester Tabbutt reported:

> Scouting and investigative work have been continued in a systematic manner as a means of detecting any new infestations or changes in existing conditions on the ground. Early detection of any "hot spots" that may occur will enable us to initiate such cutting operations as may be desirable, without undue delay. The increasing demands for National Forest stumpage, both softwood and hardwood, are being

[17] *Granger, C. M. Assistant Chief, U.S. Forest Service. Letter to Regional Foresters and Directors. November 16, 1945.*

> utilized to the fullest possible extent to remove mature, overmature and decadent timber and thereby improve the vitality of the residual stands (Tabbutt 1947).

According to available records, Region 7 had yet to use DDT in its national forests.

Forest pests seemed to build up and become more widely distributed in Region 9 during 1946. The redheaded pine sawfly had long been a pest in the Lake States forests and now was breaking out on the Shawnee. In fact, several foresters questioned further planting of pines because of problems in general in plantations. Both the redheaded pine sawfly and Saratoga spittlebug were serious problems, and white pine weevil and Nantucket pine tip moth populations were on the upswing.

DDT in an oil solvent was sprayed by air against the Saratoga spittlebug on more than 2,500 acres in the Nicolet, Ottawa, and Manistee (appendix II, p. 45–46). DDT-oil and DDT-wettable sprays were applied both by air and by hand against the redheaded pine sawfly in the Manistee, Hiawatha, Chequamegon, and Shawnee. In July of 1946, a few lab-reared parasites obtained from the Dominion Parasite Laboratory, Belleville, Ontario, were released against the sawfly in infested areas (Wales 1947).

Region 9's 1946 annual report gave tentative plans for the 1947 control program, which showed a potentially enormous increase in the use of air-applied DDT: ". . . it will probably be necessary to spray approximately 13,800 acres" (4,300 acres of spittlebug and 9,500 acres of sawfly infestations). The Assistant Regional Forester further estimated that the cost of insect control in 1948 might be as high as $30,000 and suggested that such an amount ". . . be earmarked for this work" (Wales 1947).

Because Region 9 was still understaffed after the War, the report concluded by stating that in the past land managers had depended heavily on the BE&PQ's Division of Forest Insect Investigations ". . . but the problem has now become so large that we cannot very well expect that office to handle all of the various phases of work the job entails." The annual report recognized the need for more "Technically-trained personnel, who can spend full time on the job making reconnaissance of infested areas and determining insect abundance. . . ." The report called these personnel ". . . essential to any evaluation of potential damage sufficiently accurate to enable adequate planning for control." The Assistant Regional Forester promised that estimates for FY 1948 would include funding for such a position (Wales 1947).

The year 1947 was, as predicted, the largest spray year in Region 9 since the late 1930's—more than 18,500 acres—but now applications were easier because foresters depended less on hand spraying and more on the biplane. Bids were taken for aerial spraying and low bidders on most of the flying were the Safeway Crop Dusting Company of Decatur, Illinois, and Air-Spray of Eagle River, Wisconsin (Jones 1948). Regional pioneers in DDT and airplane control were H. A. Bess, C. B. Eaton, and D. M. Benjamin.

Airplanes and DDT led to a swan song for arsenicals in 1947. Although more than 2,000 redheaded pine sawfly-infested acres had been hand sprayed with lead arsenate in 1946, only 87 acres (in the Nicolet) were hand sprayed in 1947—possibly from leftover supplies (appendix II, p. 45–46, 47–49).

More than 2,000 acres were aerially sprayed to control the redheaded pine sawfly on the Chequamegon during the summer of 1947. The degree of success using a 1/2 lb/acre DDT mixture ranged from 0 to 50 percent, however, necessitating some respraying by air (using a 1-pound mixture on 75 acres, which was reported to be 100 percent effective) and by hand (using a 1/4-pound mixture on 416 acres, which was 90 to 98 percent effective). Chequamegon's Acting Forest Supervisor Halvorson (1947) reported encountering problems other than initial poor aerial spray results. For example,

> Poor distribution of the spray was encountered soon after the start of the job, due partly it is believed, to wear in the pumping apparatus on the plane, and partly to clogging of the nozzles. . . .
>
> When an attempt was made to use Highway 77 as a landing strip, the plane nosed over, damaging it sufficiently to put it out of commission for a week, delaying the job (Halvorson 1947).

The Shawnee was also sprayed for the sawfly that year, but Bess and Eaton (1948) reported that the control was erratic.

G. W. Jones (1948), Chief, Division of Timber Management, described the aerial treatment of the spittlebug in the Nicolet and Ottawa as "very successful." He reported that inconsistent aerial spraying results against the redheaded pine sawfly "can be attributed to the size of the globules of oil spray as

they struck the trees and insects. . . . Some experimenting which was done using various types of nozzles under different pressures seems to bear out this contention." After experimentation "to determine the minimum effective dosage" to control the sawfly, Bess and Eaton (1948) concluded that 1/2 to 1 pound DDT in 1 gallon of spray per acre was satisfactory. If properly applied under favorable conditions, the lower dosage was ample—"especially if the larvae are not beyond the 4th instar."

While Region 9 was going ahead full throttle with DDT spraying, Region 7 was able to continue applying silvicultural controls. Except for the bronze birch borer, Region 7 had no insect epidemics. An extremely cold winter in 1947-1948 held in check insects like the beech scale (Mattoon 1948).

The Forest Pest Control Act of 1947 (16 U.S.C. Sections 594-1 to 594-5) established a definite pest control policy for all forest land in the United States. It was especially significant because it recognized the need to detect dangerous pests and provide for the control of outbreaks. "The language of the Act [reflected] the enthusiasm for direct, usually chemical, means of pest control" (National Academy of Sciences 1975). It also provided for pest-control cost-sharing—whereby cost of control on privately owned land could, under certain circumstances, be subsidized by Federal funds. The Act further provided funds for insect surveys ". . . to detect and appraise infestations of forest insect pests and tree diseases, to determine the measures which should be applied on such lands . . ." (USDA 1978). Incidentally, there were no direct provisions in the law for research.

As the 1940's neared an end, DDT remained the prevalent insecticide for most forest pests. Foresters had learned that DDT cost less and was generally less toxic than other previously used chemicals, resulting in its becoming overemphasized in the minds of some. In 1948, about 7,500 acres in Region 9 were treated against infestations of the spittlebug (aerial spraying) and redheaded pine sawfly (hand and aerial spraying). Spraying equipment had improved considerably by 1948—the airplanes were better equipped and able to carry larger loads than in the past and were flown by first-rate pilots. One airplane in Region 9 developed engine trouble during spraying, however, and the pilot and plane came down in the trees. The plane was a total loss, but fortunately the pilot escaped serious injury.

Major personnel changes occurred in 1948—Henry A. Bess, head of the Division of Forest Insect Investigations of the BE&PQ went to work in Hawaii and Charles B. Eaton, an entomologist at the Forest Insect Laboratory, Beltsville, Maryland, who had previously worked closely with Bess, took his place as Entomologist in Charge at the Milwaukee Laboratory. Daniel M. Benjamin[18] of the Milwaukee Laboratory was also a major advisor to the Forest Service concerning insect infestations during this period (Jones 1949). Frank C. Craighead retired in 1950 after 30 years of service as head of the Bureau. He was succeeded by James M. Beal.

In 1949, Region 9 experienced insect infestations similar to those in 1948; about 8,700 acres were sprayed with DDT to control the redheaded pine sawfly, larch sawfly, and Saratoga spittlebug.

"Chlordane, the first of the cyclediene insecticides . . ." (Telford 1967), was developed in 1945 and used in 1949 as poison bait to control grasshoppers on nearly 1,300 acres in the Manistee. This treatment, in addition to 30 Hiawatha acres treated with ammonium sulphate, marked the last year that grasshopper control was conducted. In the 1949 annual report the Assistant Regional Forester wrote, "The Region now has two mistblowers, which should permit treating areas up to 100 acres very effectively" (Ochsner 1950). This equipment was a boon to foresters, for while the cost was comparable to spraying by plane, the mistblower could be used when spraying by plane was impractical. Mistblowers were used on 440 acres in the Chequamegon, Hiawatha, and Manistee that year.

In a 1950 letter to division chiefs, W. S. Swingler[19] summarized Region 7's previous 5 years of insect control as follows:

> Practically all pulpwood operations during the past five years have been to salvage the spruce and fir infested with

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[18]*Benjamin and others have published summaries of the insecticide use in Wisconsin forests from 1926 to 1976. Their three University of Wisconsin-Madison Forestry Research Notes are as follows: Daniel M. Benjamin, Donald W. Renlund, and Donald C. Schmiege, "A brief history of the use of insecticides in Wisconsin forests," No. 98, April, 1963; Daniel M. Benjamin, Donald W. Renlund, and Imants Millers, "Insecticide use in Wisconsin forests: 1963-1968," No. 146, April, 1969; and Daniel M. Benjamin and Donald W. Renlund, "Insecticide use in Wisconsin natural forests and plantations: 1969-1976," No. 198, December, 1976. The fourth note in the series, covering 1977 to 1984, is currently being prepared.*

[19]*Swingler, W. S., R-7 Regional Forester. Memo to Division Chiefs. October 9, 1950.*

> the spruce budworm and fir bark louse [*Chermes piceae* Ratz.], and to provide resistance to these insects. The cuttings have been made in accordance with the recommendations of entomologists and research silviculturists.

Clearly foresters were polarizing into two factions—those who used silvicultural methods and those who were spraying chemicals. Foresters in Region 7 remained conservative.

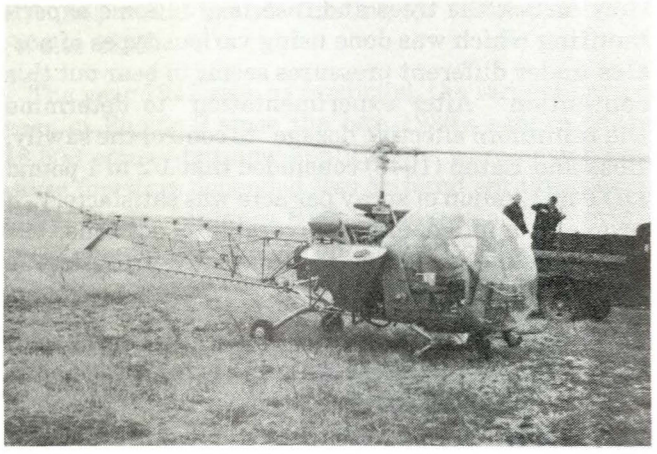
The decade of the 1950's was not long underway when the Chief of the Division of Timber Management, Ira J. Mason, wrote to all Regional Foresters as follows:

> Mr. Carter's S-Control, Insect memoranda of December 6, 1932 and September 28, 1939 itemized the data to be submitted to this office on insect control work accomplished annually.
>
> We wish to restate these instructions and bring them up to date with the conditions that now prevail.
>
> The main purpose of the data is to furnish this office with information on accomplishments and expenditures. Narrative is *not* desired, but rather factual data in tabular form.[20]

The 15 main types of data required were to be submitted on a calendar year basis by November 1 of each year and included: control expenditures, percent of reduction obtained, and number of worker days used (in control work) on the project.

The reports in response to Mason's directives from Regional Foresters in Regions 7 and 9 showed that the 1950's, like the late 1940's, were almost totally DDT years. For example, white pine weevil was treated for the first time in Region 9 in May of 1950 when a Bell helicopter sprayed Manistee plantations with DDT-oil solutions. In August of the same year, the walkingstick in the Nicolet was sprayed with DDT by plane—that treatment was the only insecticide treatment ever to be used against the walkingstick in an Eastern Region national forest.

In July of 1951, Region 7 tried helicopter spraying with DDT at 4 gallons per acre on 71 Allegheny acres to control the European pine shoot moth. Although the helicopter pilot did an exceptionally thorough spray job and the spray was applied at the proper time with no wind movement, the results were disappointing. However, McIntyre (1951) stated that a simultaneous knapsack spraying treatment on 235 ornamental red pines (1/4 acre) at 64 gallons per acre was highly successful. He concluded:



*Bell helicopter at loading point taking on 50 gallons of DDT spray for use against the white pine weevil in jack pine plantations in the Manistee National Forest in May 1950.*

> It appears that a large volume of spray is required to effect satisfactory control of [the pine shoot moth]; volumes which would be entirely impractical to apply with helicopters or hydraulic equipment except on small ornamental plantings of high value.

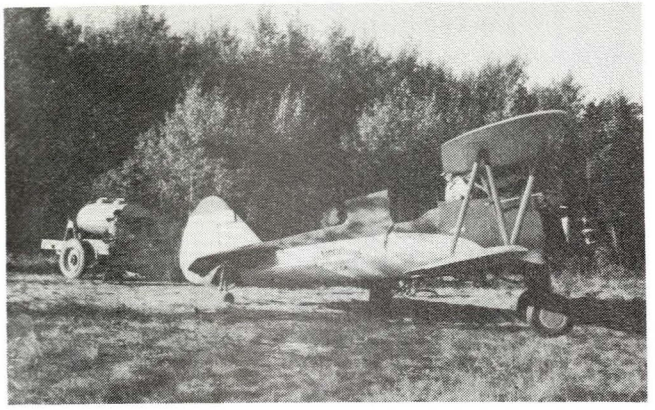
R. C. Brown, Entomologist in the BE&PQ, New Haven, Connecticut, wrote a memorandum to those interested in the control of the pine shoot moth by the use of aircraft:

> It seems to me that the only practical method of combatting the shoot moth problem is to refrain from planting red pine in those areas where the shoot moth can survive low winter temperatures. Our surveys are designed to determine the location of such areas in the Northeast.[21]

One of the recipients of the memorandum, Acting Regional Forester Mattoon (R-7), remarked, "Inasmuch as we have used red pine quite extensively for

[20] *Mason, Ira J. Chief, Division of Timber Management. Letter to all Regional Foresters. April 19, 1950.*

[21] *Brown, R. C. Entomologist, New Haven, Connecticut. Memo to Dr. J. A. Beal, Entomologist in Charge, Forest Insect Investigations, Beltsville, Maryland. October 8, 1951.*



*Stearman used to treat the walkingstick with DDT. The biplane was fitted with a boom and nozzle attachment beneath the lower wing, and a wind-driven positive displacement pump was mounted on the landing gear. Photo by Charles B. Eaton.*

*Plane spraying walkingstick-infested hardwood stands in the Menominee Indian Reservation—the treatment was highly successful. Photo by Charles B. Eaton.*

planting and until recently have considered it one of our most desirable species, we have requested Dr. Brown to keep us advised as to the results of his surveys in this respect."[22]

The shoot moth on the Allegheny attracted much attention again in July of 1953, when Region 7 requested $1,000 from the Washington office to ". . . go into some of the less heavily infested plantations to remove with hand labor the affected branch tips of some of the trees or remove heavily damaged trees entirely. There are now 145 acres of known affected red pine plantations."[23] After much correspondence and delay (due, in part, to the BE&PQ being low on travel funds), Tom McIntyre of BE&PQ reexamined the plantations sprayed in 1951 and decided that Region 7's suggested control measures were not feasible because (1) the trees were too tall for close examination of branch tips and terminal buds; (2) adequate control required complete eradication within a plantation, not partial as was suggested; and (3) the requested $1,000 would control about 8 or 10 acres, far short of an effective job. At least temporarily, Allegheny foresters abandoned the plan to "eradicate" the European pine shoot moth from the forest's plantations.[24]

Although the gypsy moth was first introduced into the country and the Eastern Region in Medford, Massachusetts, in 1869, available records show that it was never chemically treated in any of the 16 Eastern Region national forests until 1954 when it was sprayed with DDT on 410 acres in the White Mountain (appendix II, p. 53). (Although the White Mountain again used chemicals against the gypsy moth in 1970 and 1972, the only documented treatment in another Eastern national forest occurred in 1974 when carbaryl was used on 800 gypsy moth-infested Manistee acres.)

In 1957, the pine shoot moth was again a problem in Region 7 when $750 was requested from Washington to handpick or prune and burn buds in 40 infested Allegheny acres. The Northeastern Station had approved the control method, believing that it "might save an expensive aerial control job later."[25] Similar work was allotted $2,000 for June of 1958.[26] Unfortunately, no existing Region 7 reports confirm that the control work was completed.

The East was not the only area in which entomologists recommended silvicultural controls to prevent damage by insects. In the early years Graham recommended cultural methods, but later he summarized the history of the Lake States forests as one of extremes: (1) rapid and wasteful logging, (2) burning and reburning to keep unsuited forest land open for agriculture, (3) replanting with too much of the same species and age class on contiguous

[22]*Mattoon, M. A. Acting Regional Forester, R-7. Memo to the Chief, Forest Service, WO. October 25, 1951.*

[23]*Olson, Roy W. Acting R-7 Regional Forester. Letter to the Chief. July 3, 1953.*

[24]*Costley, R. J. Forest Supervisor, Allegheny National Forest. Memo to the Regional Forester. October 22, 1953.*

[25]*Olson, Roy W. Acting R-7 Regional Forester. Memo to the Chief. June 10, 1957.*

[26]*Olson, Roy W. Acting R-7 Regional Forester. Letter to Supervisor, Allegheny National Forest. April 7, 1958.*

areas, and (4) relying too much on insecticides to control infestations caused by careless planting (Graham 1956). He asserted:

> Far too much reliance is being placed on the effectiveness of insecticidal treatments, because they are direct and easily understood, and too little to the possibilities of controlling insects by less spectacular silvicultural practices. As a result, wide-spread spraying programs are often entered into without much thought of either the ecological or economic implications.

While a general rule among forest managers in the late 1950's seemed to be "if there's a problem, spray it," a few silviculturally oriented foresters continued to try new methods such as Region 9's interplanting of aspen with white pine to protect the latter from the white pine weevil. Chemical treatments did not control the weevil and other measures were needed. Todd (1958) reported that this pest and others such as the shoot moth ". . . preclude the advisability of establishing new red or jack pine plantations. . . ."

As the 1950's came to a close, however, Region 9 planned a good deal of chemical control ". . . within the limits dictated by economic and biologic considerations. . ." (Hermel 1959). R-9 foresters expected to spray about 49,000 acres against the Saratoga spittlebug, pine sawflies, spruce budworm, and European pine shoot moth, with 50 acres each to be field tested against the white pine weevil and the Zimmerman pine moth (*Dioryctria zimmermani* (Grote)). Estimated total cost for this proposed 1960 control was $126,500.

According to available records, in 1960 actual control in the 16 Eastern national forests was much less—about 29,000 acres (fig. 2). Although it had been estimated that more than 41,000 acres would be sprayed for spruce budworm, for instance, actually just more than 24,000 acres (in the Superior) were treated. Nevertheless, the new decade started off with a bang because 1960 was the largest spray year to date. In fact, the early 1960's were the years of highest chemical control in the history of Eastern national forests. One contributing factor was the "every tree must grow to maturity" philosophy, particularly in plantations during this period. The thinking was that the time and money invested in planting each tree would be wasted if the tree did not mature. Perhaps another contributing factor was that pest control was financed from a separate fund and not by the forest or ranger district. If ranger districts had been required to budget for pest suppression, forest personnel might have thought twice about the cost of insect control if it meant cancelling their other work. Nevertheless, some foresters and entomologists resisted political and other pressures

*Hydraulic sprayer applying DDT to control the European pine shoot moth in the Manistee National Forest in 1957.*

> to treat areas with chemicals when it was clear to them that treatment would not be needed and could have undesirable side effects. For example, when questioned by the Chippewa and Superior National Forest Supervisors, [A. C. Hodson] explained to them that . . . our long-term studies showed no serious stand damage if most of northern Minnesota was not sprayed for forest tent caterpillar control.[27]

[27] *Hodson, A. C. Professor Emeritus, Department of Entomology, University of Minnesota. Letter to Richard Fowler. July 13, 1984.*

*Forest worker spraying red pine with a backpack mistblower.*

He suggested the most that should be done would be to treat campsites and some resort areas (a large-scale shade tree project).

Although Region 7 records for this period are incomplete, we do have evidence that forest entomologists did some control work in the first half of 1961. A pest control accomplishment report to the Chief (R-7 Forester 1961), for instance, shows the following forests spent a total of more than $3,100 on these specific insects:

| | | |
|---|---|---|
| Allegheny | white pine weevil | $1,809.73 |
| Green Mountain | balsam woolly aphid | 500.00 |
| Monongahela | larch sawfly | 17.59 |
| | white pine weevil | 293.00 |
| White Mountain | balsam woolly aphid | 500.00 |
| | | $3,120.32 |

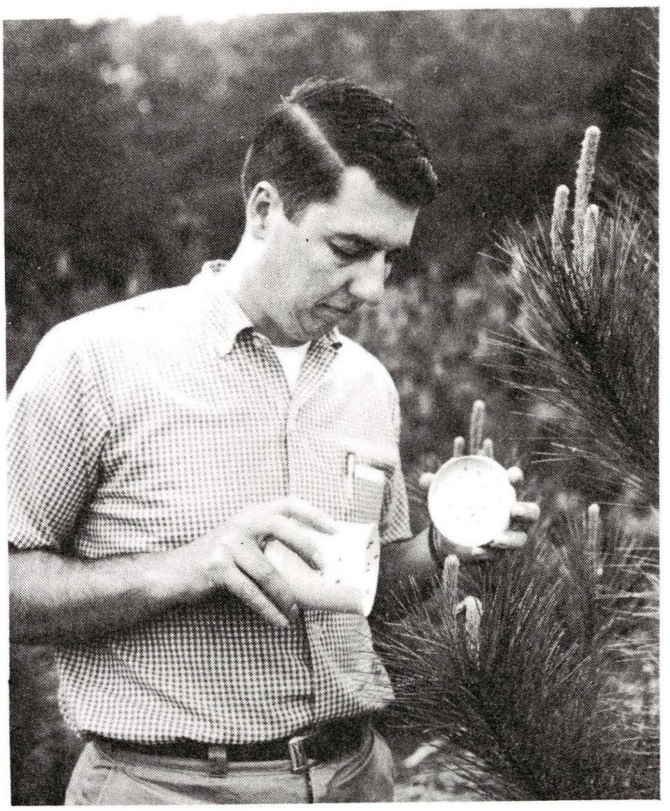
The $1,000 spent against the balsam woolly aphid (really an adelgid) (*Adelges piceae* (Ratz.)) on the Green and White Mountain Forests was probably for biological control. In 1961 forest entomologists released 10,000 adult *Laricobius erichsonii* (Rosen.) beetles (imported from Germany) in these two forests and in Maine. The beetles were dispersed at 20 different locations as colonies of 500. While early indications showed that the beetle release was successful, foresters planned that the beetles' effectiveness against the aphid would be evaluated for several years after their release to help decide future aphid suppression efforts.

During this time, the managing editor of *Organic Gardening and Farming* wrote to Region 7 expressing concern about the possible ill-effects of mass spraying on American bird life.[28] Roy Olson, Assistant Regional Forester, answered, in part, as follows:

> We hold, as our primary objective, the control of forest insects and diseases by silvicultural and management practices. The use of direct control methods employing chemicals by mass application is a last resort.
>
> In the Northeast we have had very few control projects employing aerially dispersed chemicals. The areas have been small and great care is used to apply the chemicals only in the place where they are needed.[29]

[28]*Franz, Maurice. Managing Editor,* Organic Gardening and Farming. *Letter to S. P. Shaw, Forest Service, Upper Darby, Pennsylvania. March 1, 1960.*

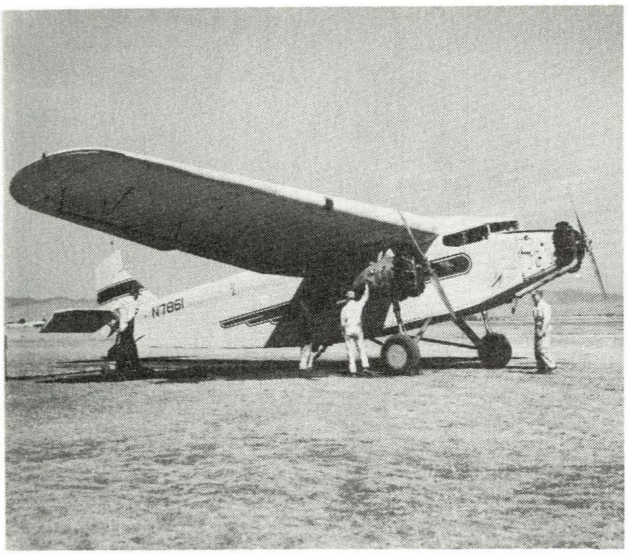
[29]*Olson, Roy W. Assistant Regional Forester. Letter to* Organic Gardening and Farming. *March 11, 1960.*



*Author Wilson releasing parasites to control European pine shoot moth in the Manistee National Forest.*

Ironically, 1962, the year Rachel Carson's book *Silent Spring* first appeared in hardback, was also the largest spray year in what is now the Eastern Region—DDT was being sprayed on more than 104,000 acres of the total of 109,000 acres sprayed that year (fig. 2). That year major control projects took place against the spruce budworm (56,000 acres on the Superior), jack pine budworm (37,000 acres on the Chippewa and Hiawatha), and pine tussock moth (8,700 acres on the Chequamegon).

The spruce budworm continued to receive attention in Minnesota on the Superior National Forest in 1963. In June of that year, Assistant Regional Forester St. Amant (1963) summarized a number of current reports by writing, "The Superior National Forest is treating 40,000 acres along scenic roads and in campgrounds" for the spruce budworm. Although some or all of this spraying may have taken place, we do not have records showing its completion. A table submitted to the Regional Forester by Superior's Forest Supervisor Neff (1963) showed that 1,938 pounds of DDT used on the Superior were paid for by Federal Insect and Disease Control funds in FY 1963. We calculated that at the rate of 0.5 lb/acre, more than 3,800 Superior acres were treated



*A Ford Tri-Motor similar to the one used for spraying 8,735 Chequamegon National Forest acres with DDT against the pine tussock moth in 1962. This plane had a carrying capacity of 400 gallons.*

with DDT for the spruce budworm that year (appendix II, p. 46).

As for another pest in Region 9, Ryan (1963) reported that the 1962 spraying on the Chippewa had reduced the jack pine budworm population by 98 percent. On the Hiawatha, Millers (1963) found the jack pine budworm ". . . at a low level, and with intensified elimination of open-field jack pine, chances of future outbreaks will be reduced." However, Van Denburg (1963) reported that although control efforts were needed in 1963, population levels had increased drastically in the Huron-Manistee National Forests late in the year and said that tentative plans for 1964 called for large spray programs against the budworm.

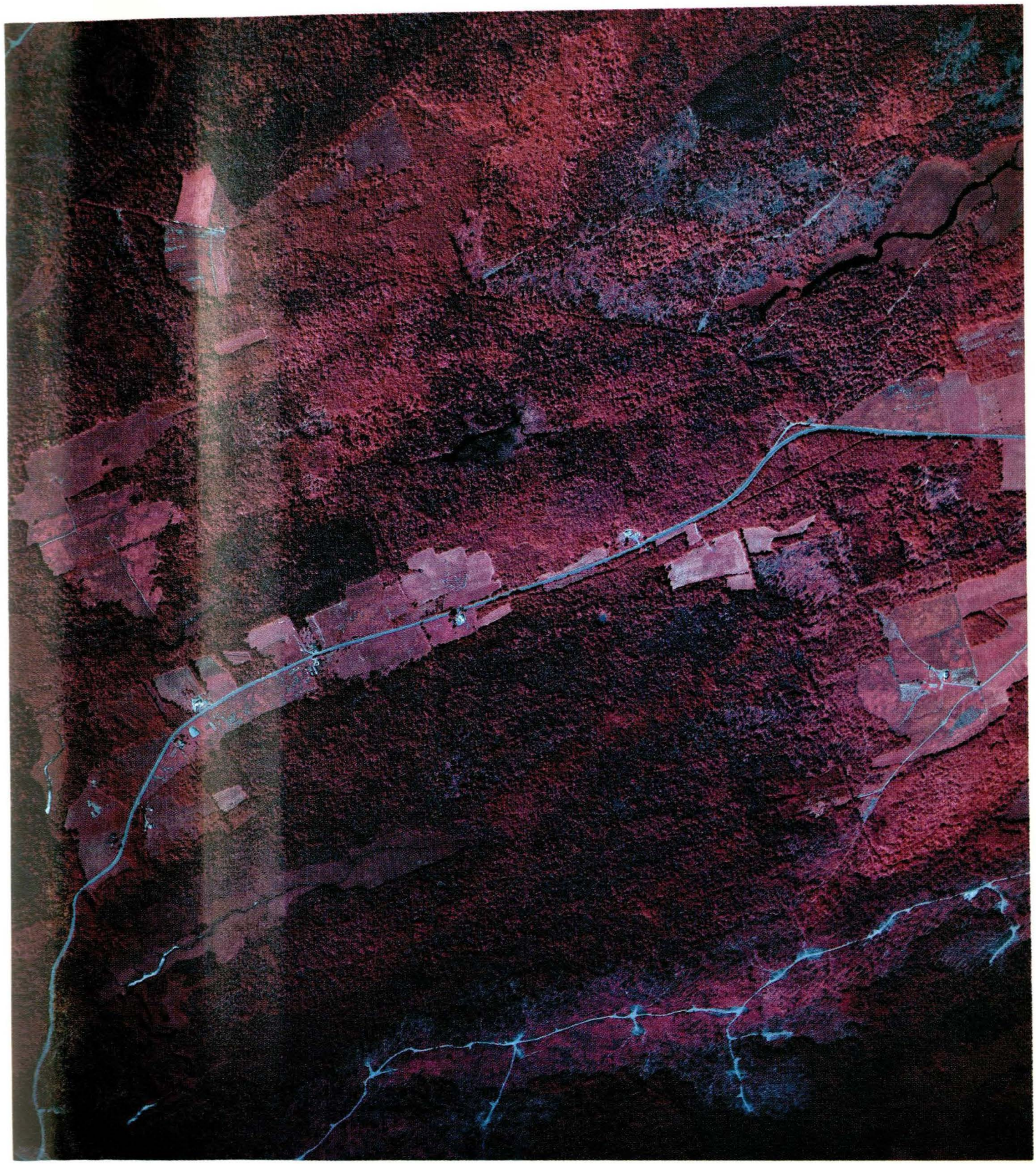
The pine tussock moth, which had achieved attention on the Chequamegon in 1962 (8,735 acres were sprayed with DDT), had declined greatly by spring of the next year (St. Amant 1963). During this same period, the Hiawatha had a severe pine tortoise scale infestation. After watching dominant and other jack pines die and noting that salvage control in 1963 had failed to halt the problem, foresters managed this situation by cutting and burning several "40's." Private landowners in the area of the Hiawatha did nothing about the infestation, and, contrary to what might have been expected, their trees survived and even grew to saw-log size.

Although Region 7 annual reports for the early 1960's are not available, in Region 9 a new wave of conservative use of insecticides became evident in 1964—no doubt in part as a reaction to *Silent Spring*. This cautious attitude was apparent in a letter written in April by R-9's Regional Forester George S. James. He listed the 1964 insect control projects approved by the Federal Pest Control Review Board against the spruce budworm on the Superior (DDT on 2,600 acres); the Saratoga spittlebug on the Chequamegon, Nicolet, and Manistee (DDT on 210, 890, and 200 acres, respectively); and the jack pine budworm on the Huron-Manistee (malathion and dimethoate as needed) and then noted:

> Special precautions (buffer strips) are to be observed along streams and other sensitive areas. The jack pine budworm infestation on the Huron National Forest, Michigan, involves the nesting habitat of the Kirtland's Warbler. No spraying will be done . . . within two miles of any known nesting sites. . . . Malathion will be applied by helicopter. . . .
>
> A number of new insecticides are being field tested on the Huron-Manistee N. F.'s. Dimethoate (Cygon), Malathion, Sevin, and Guthion are scheduled this spring. . . .
>
> Your help in providing any pesticide evaluation techniques, especially involving the fisheries resource, would be appreciated.[30]

A July report from Acting Assistant Regional Forester Moore (1964) showed a reversal of thinking about spraying against the spruce budworm, "The 4,000 acres proposed for control on the Superior were not sprayed as a result of a reassessment of involved recreational values." Available records show no control against the Saratoga spittlebug on the Chequamegon, Nicolet, or Manistee in 1964. Similarly against the jack pine budworm, Moore (1964)

[30]*James, George S. Regional Forester, R-9. Letter to Robert W. Burwell, Regional Director, Bureau of Sport, Fisheries and Wildlife. April 28, 1964.*



*Infra-red photograph of spruce budworm defoliation. The bright red indicates hardwoods and the maroon indicates fir and spruce. Gray indicates tree mortality.*

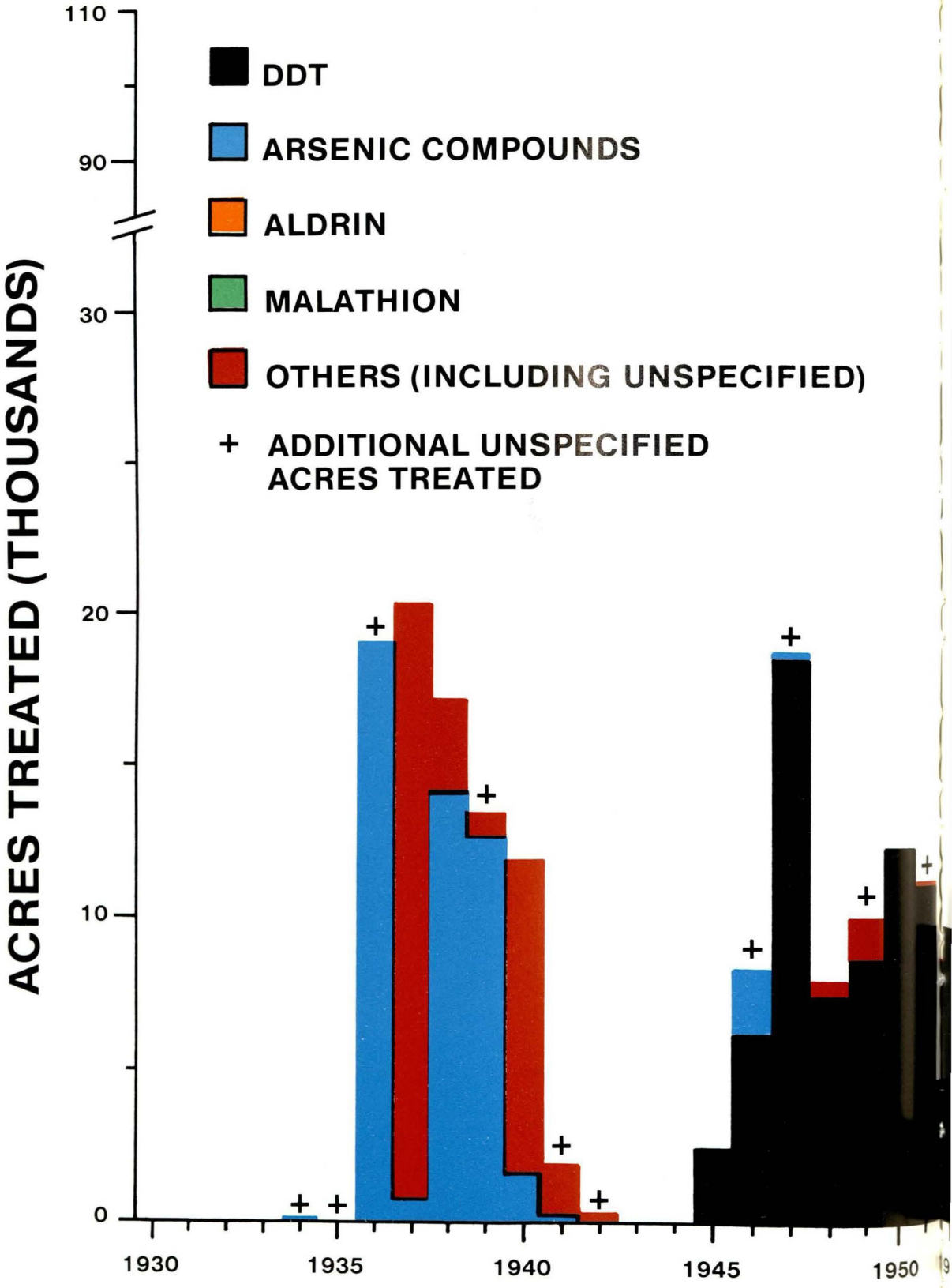
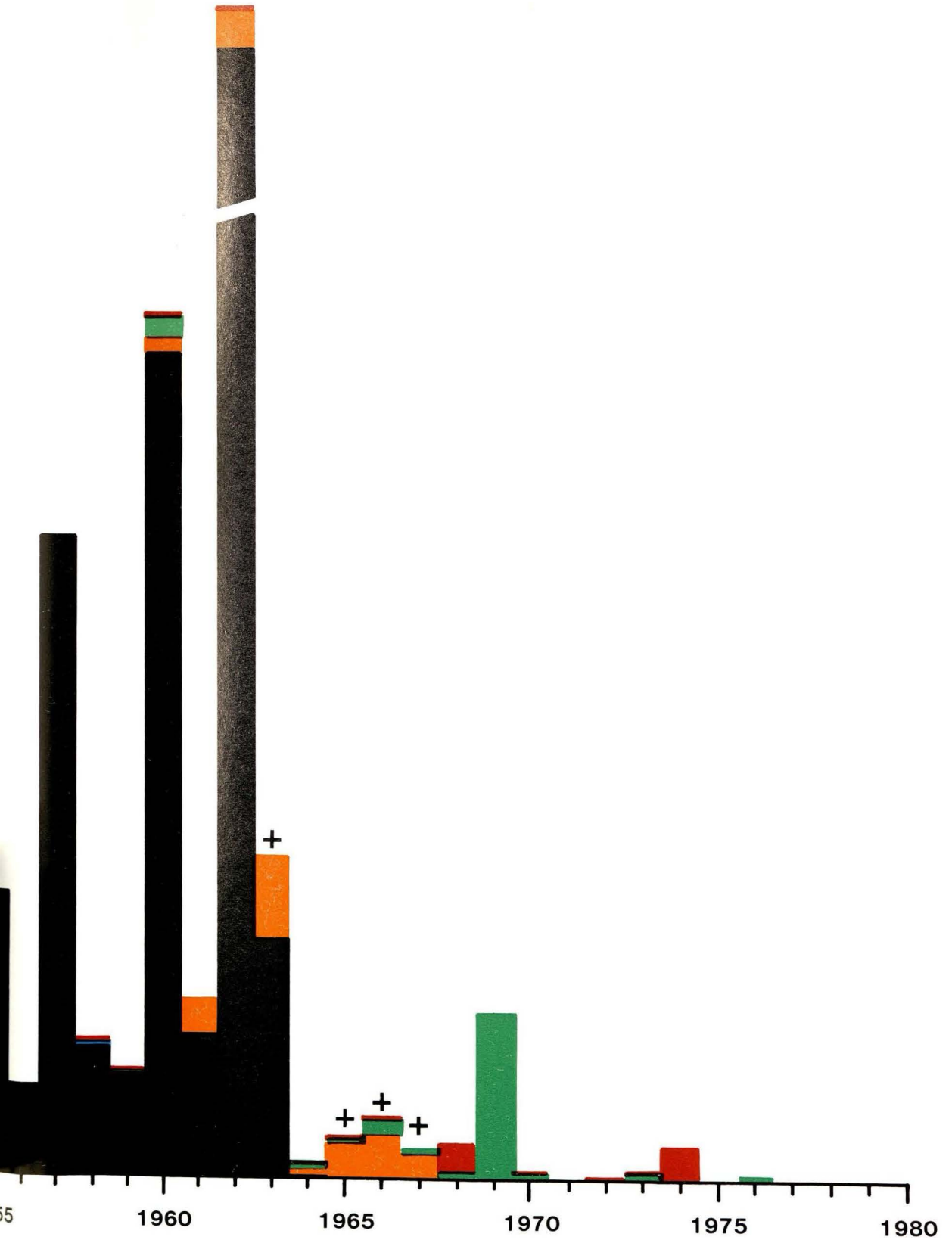



Figure 2.—*Acreages of Eastern Region national forest land treated with insecticides by years, 1930-1980.*


55
1960
1965
1970
1975
1980

wrote, "The anticipated control project on the Huron-Manistee did not materialize."[31]

Final figures for 1964 showed that in the Region's 16 national forests about 500 pounds of chemicals were sprayed. Of these, only 64 pounds were DDT, which was used (experimentally) against the jack pine budworm and the Saratoga spittlebug (60 acres on the Manistee and 4 acres on the Huron, respectively, appendix II, p. 50 and p. 44). These two tests (Batzer and Millers 1965, Millers and Wilson 1965) concluded the use of DDT in the Eastern national forests. Eichers *et al.* (1968) found that during 1964 farmers in 19 of the 20 Eastern Region States (records for West Virginia were unobtainable) used more than 25 million pounds of various insecticides to control crop and livestock pests, including more than 2.1 million pounds of DDT. They also reported that "... total insecticide production has increased an average of about 5 percent a year in the last 4 years." A State and Private Forestry (S&PF) report late in 1964 showed that foresters continued to have plans for future spraying: "The Huron-Manistee National Forest has proposed 62,000 acres for possible control [of the jack pine budworm] in 1965" (S&PF 1964). But DDT was almost totally out of favor with foresters, and DDT substitutes such as malathion were to be field tested at this point.

Thus the golden, yet well-tarnished, age of DDT ended in what is now the Eastern Region. Long-time proponents of silvicultural control and timber sale activities were once again listened to, and the foresters and entomologists of the Eastern Region Forests were developing an integrated pest management future.

[31]*In a January 8, 1965, letter to Les Line, Secretary of the Michigan Audubon Society, Acting Forest Supervisor D. D. Westerburg explained why the control project was cancelled:*

> *The pilot control test proposal was turned down because of insufficient funds available at the Washington Office. Recent fires and windstorms have produced extensive bark beetle outbreaks on the Western Forests. Bark beetle control is considered more important than suppression of defoliators, and consequently, no funds remained for the jack pine budworm pilot test.*

## The Post-DDT Era

## (1965-1980)

The final 15 years of this study—the post-DDT era—demonstrate an overall emphasis on the economic and ecological aspects of control; foresters began to work towards intensive forest management including integrated pest management (IPM). In this history, IPM is defined as a forest management system that considers all possible pest control techniques and methods (e.g., cultural, chemical, biological, legal, mechanical) to keep insect populations below economically injurious levels.

The concept of IPM was not embraced immediately when the use of DDT was phased out. As Newsom (1980) states, "The basic principles of biology and ecology were largely forgotten or ignored" during what he calls the "Dark Ages" of integrated pest control (the late 1940's through the mid-1960's) when "... pest management consultants [functioned] essentially as 'pesticide peddlers.'" It would take time for attitudes and procedures to change in order to bring back and improve upon early IPM systems such as one that Dwight Isely developed against the boll weevil (*Anthonomus grandis grandis* Boheman) in the south in the 1920's.

Blair and Edwards (1980) found that

> Major problems from the late 20's until late 60's that hindered the growth of IPM were: (1) no widespread environmental concerns, (2) lack of insecticide resistance problems, (3) inexpensive and readily available insecticides, and (4) lack of adequate money for IPM program development and personnel in both research and extension.

No doubt the issuance of the 1965 report "Restoring the Quality of Our Environment" by President Lyndon B. Johnson's Science Advisory Committee helped confirm the USDA Forest Service's

> ... policy of not using persistent pesticides in action programs to control forest insects in all cases where research and field tests have demonstrated that a commercially available non-persistent chemical or non-chemical methods will accomplish a control job effectively and safely (USDA Forest Service 1966).

The foreword to the report *Forest Insect Conditions in the United States 1965* gave a stringent admonition:

> The Forest Service also warns that pesticides if improperly used can be injurious to humans, fish, and wildlife; that the directions and precautions governing their use should be closely followed; and that overdosing is dangerous and should be avoided. Special care should be taken in applying pesticides along the edges of rivers and streams, around ponds and lakes, and in grazing and foraging areas (USDA Forest Service 1966).

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321, 4331-4335, 4341-4347) definitely made a large impact on forest insect control in the post-DDT era:

> The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality (USDA 1978).

A main provision of this Act was the requirement of an environmental impact statement to be included "in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment" (USDA 1978).

A second major act during this era was the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended in 1972. Under this Act, the Environmental Protection Agency required the certification of applicators and the registration of all chemicals (USDA 1983).

As part of the growing concern about the environment, forest entomologists in the mid-1960's began experimenting with chemicals that were far less toxic than DDT, had a lower residual life, and usually could be applied in smaller dosages. For example, Wilson and Millers (1966) tested the application of malathion with a helicopter in 1965 and found that low-volume malathion (10 fluid ounces per acre) reduced a spittlebug population by more than 99 percent. Van Denburg (1965) reported that the low-volume malathion might ". . . revolutionize spittlebug control in the Lake States." While various proposals for 1965 called for chemical control of pests on more than 60,000 acres, available records show that about 1,500 acres were actually treated (Fowler 1973a, 1973b).

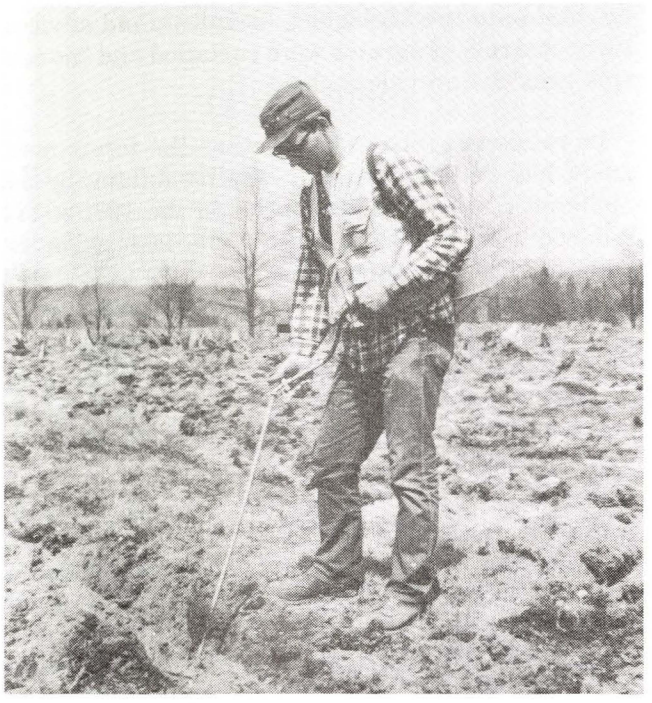
Concern about DDT remained strong the next year in the Forest Service. For instance, in August 1966 District Rangers on the Ottawa received a memorandum stating, "We can no longer use DDT for control. A solution of lead arsenate in water is being recommended for use as a control measure" against the redheaded pine sawfly.[32] Also, later that year a Lake States report referred to "the continuing search for a replacement for DDT" (USDA 1966). Foresters did spray more than 2,000 pounds of four other insecticides during 1966—aldrin, malathion, lindane, and carbaryl (appendix II). At the time, Eastern Region farmers reduced their use of DDT from more than 2.1 million pounds in 1964 to about 1.5 million pounds in 1966 (28 percent reduction), but overall use of insecticides by farmers was up from more than 25 million pounds to nearly 35 million (39 percent increase) (Eichers *et al*. 1968, Eichers *et al*. 1970).

In 1967, the Forest Service as a whole continued its ". . . efforts to use safer, more effective control methods for economically important forest insects." They placed greater emphasis on biological control techniques and ". . . continued to screen and test nonpersistent pesticides for use in suppressing forest defoliators" (Pierce 1968).

The Forest Service in 1968 again stressed control techniques that relied less on the use of chemicals—particularly biological and cultural controls. Pilot studies on non-persistent pesticides continued to be conducted during that year. According to Robert G. Doerner (1968), who compiled the Region's annual report, defoliators were again the worst pests in the Eastern States—"Of the 22 forest pest problems encountered, 14 were related to defoliators."

Although the Forest Service sprayed a larger amount of insecticide in 1969 than it had for 5 years, it used only malathion. That chemical was sprayed on more than 5,500 acres (fig. 2), in particular,

[32] *Kickbusch, William L. Timber Management Staff Assistant. Memorandum to District Rangers. August 11, 1966.*



*Forest technician injecting aldrin into the soil with a wand for white grub control in a Hiawatha National Forest red pine plantation in 1967.*

against the Saratoga spittlebug on the Chequamegon, Hiawatha, and Huron (appendix II, p. 44).

That was the last year that chemicals in very large amounts were used in the Eastern Region national forests. In March of 1970, a number of suppression programs were planned in the Lake States, including a 373-acre project on the Chequamegon against the Saratoga spittlebug.[33] Existing records show that only 61 acres (fig. 2) actually were sprayed. Chemicals were used against the gypsy moth in the White Mountain (carbaryl on 15 acres) and against the redheaded pine sawfly in the Manistee and Ottawa (malathion on 45 acres and 1 acre, respectively) (Fowler 1973a, 1973b).

The next year no insecticides were used in Eastern Region national forests, and in 1972 only 12 acres were sprayed—carbaryl was used on the White Mountain against the gypsy moth (appendix II, p. 53). The only spraying on Eastern Region national forests in 1973 was experimental on 120 acres—four chemicals were tested against the redhumped oak-

[33]*Hastings, A. R. Entomology Section Head, St. Paul Field Office, S&PF. Letter to Dr. James B. Elder, U.S. Fish and Wildlife, Pesticide Monitoring. March 19, 1970.*

*Silvicultural controls such as snow-depth-pruning were used on this stand of red pine to control the European pine shoot moth in 1969. Note that the branch tips on the unpruned tree on the right are below the snow line—shoot moth larvae hibernating in these branches are insulated from the cold.*

worm (Fowler 1973b). Carbaryl was found to be the most effective in reducing the larval population of this pest.

Similarly in 1974, carbaryl was used experimentally against the cherry scallopshell moth on 225 Allegheny acres—this treatment marked the first time this insect was sprayed in Eastern forests. That same year carbaryl was also used against the gypsy moth on 800 Manistee acres (appendix II, p. 53).

No insecticides were used in the national forests of the Region in 1975, and only one was used in 1976—

*This stand of red pines has received early-basal-pruning, and duff beneath these trees has been scraped away to protect them from the pine root collar weevil. Because there is no longer shade at the bases of the trees, the weevils can't live in this environment nor lay their eggs.*

*Bell 47 helicopter being made ready for liftoff; it is equipped with two Beecomist 350 rotary spray nozzles with 100-micron sleeves.*

40 pounds of malathion against the Saratoga spittlebug on the Nicolet (appendix II, p. 46). During the same year, farmers in Region 9 used more than 23.5 million pounds of insecticide on major field crops, hay, and pasture and rangeland, down 6 percent from 1964 usage and 33 percent from 1966 (Eichers *et al.* 1978).

No chemicals were used in the Eastern Region's forests during the final 4 years of this 50-year study. The long shadow of *Silent Spring* apparently had projected deeply into the 1970's and eclipsed the attitudes of the 1950's and early 1960's. Rachel Carson's facts and forecasts had finally made their total impact.

Historically, human thought about a variety of matters has swung far in one direction, come to center, and then swung equally far in the opposite direction. This kind of pendulum swing seems to have happened to national forest pest managers who were extremely spray conscious during the DDT era, but who became concerned about the environment late in the 1970's and drastically limited spraying. *Silent Spring* helped put the philosophy of integrated pest management (IPM) onto the horizon in the early 1960's, and to the zenith by the late 1960's. In IPM, alternate control methods were considered first and "no control" was as valid a pest management recommendation as was spraying. Managers strived for IPM, but seldom, if ever, realized it because of the lack of appropriate technology as well as the presence of constraints involving environmental concerns. When forest managers had to make judgments based on whether it was economically justifiable to use biological, chemical, and silvicultural controls, programs were curtailed and "no control" was the prevalent choice.

In retrospect, one asks whether the forest managers had gone too far, like the pendulum, by not applying more chemical control in the 1970's. The reduced spraying has caused some losses. For instance, Kucera (1985) states:

> Large, outbreak-sized populations generally develop in extensive and continuous areas of mature and overmature balsam fir—the preferred host of the spruce budworm. . . .
>
> By the mid-1970's, more than 60 percent of the eastern spruce-fir forests had reached the mature or overmature stage, and this large area of susceptible hosts provided a huge source of the budworm's preferred foods: buds, male flowers, and foliage from mature or overmature trees. The outbreak, which began in the mid-1970's, peaked in 1978.
>
> . . . . . .
>
> In the Lake States, losses attributed to the latest outbreak began around 1980. From 1977 through 1982, approximately 485,000 cords (1.2 million $m^3$) were killed by the budworm. . . . These cords represent almost one-half of the spruce-fir type. The remainder of the stands are again being defoliated after a 1- to 2-year decline.

Additionally, vast acreages of jack pine in the Lake States have been killed by the jack pine budworm and deformed by the white pine weevil. Numerous red pine plantations throughout the Northeast have also been attacked by the Saratoga spittlebug, and losses there have been considerable. Other pests have also caused large losses. Because spray programs on State-owned land in many parts of the Region have not abated, we must wait for the future to decide which strategy has been the most beneficial.

As we come to the end of the first 50 years of insect suppression in the Eastern Region national forests—which incidentally is also the end of the first 75 years of the USDA Forest Service—we realize we must continue to look to the past in order to help predict the future.

## The Next 50 Years . . .

## (1981-2030)

We cannot resist making some predictions based on the past as we look forward to the year 2030, when the Forest Service will be 125 years old and the history of forest insect suppression will have reached its centenary.

Our first prediction is that forest managers will continue to use integrated pest management techniques to solve pest problems. Most managers realize that they must include pest management when they plan stand management and not depend upon expensive control procedures after various crises arise. Furthermore, the philosophy held by some forest managers that all trees must live and all harmful bugs must die will continue to change. Environmental concerns and economics will continue to be partly responsible for this change in philosophy. Insecticides will not be a thing of the past. New chemicals will be developed and used, but their use will be more carefully planned biologically, environmentally, and economically. New knowledge about (1) the pests themselves, (2) the fate of chemical insecticides in the environment, (3) herbicides needed to control overstory and understory, and (4) substitutes for chemicals will continue to shape pest prevention and suppression in the future. However, insecticide use will continue to be a vital component of integrated pest management.

The future will continue to hinge on the past. Because large acreages of single species or mixtures of closely related tree species (especially in the Lake States) were planted in the 1930's, these must be closely monitored. Although these plantations have grown beyond danger from pests such as white grubs, the Saratoga spittlebug, and the redheaded pine sawfly, they are at the age when other pests such as budworms and bark beetles will attack them. Forest managers must prepare to meet this event.

In the future, more trees will be grown under intensive culture management. Agroecosystems of hybrid *Populus* and other species could set the stage for extremely damaging insect outbreaks, and the problems may be worse than those of pine plantations in the past. Selected species or clones with limited genetic variability also may be particularly vulnerable to injury. However, intensive culture systems will be advantageous because they can allow manipulation or treatment to prevent or control pests in ways not available to natural forests or mature stands.

Sometime during the next 50 years, the gypsy moth will occupy all available ecological niches coast-to-coast, including valuable hardwood stands in Eastern Region national forests. The gypsy moth is not the only exotic pest that will affect the forests. The introduction of other new pests is inevitable and eradication will be impossible. The costs of eradicating pests—in terms of environmental damage, adverse public opinion, and actual dollars—will be prohibitive.

We believe that pest problems will be reduced overall as stands and whole forests are brought under intensive management. But this state of management is a long way into the future. The low budgets of the 1980's for national forest management and research will no doubt extend the time necessary to achieve intensive management. Although insects are one of nature's ways of harvesting overmature or overcrowded stands and making way for younger, more vigorous stands, insect harvests will continue to be as wasteful as they have been spectacular.

Finally, we predict that management will rely more on the computer, and programs will be planned through systems science approaches. Insects will be monitored by satellites; and, perhaps, pest control with lasers, genetic engineering of insect pathogens and other still-to-be-developed tools too unusual to predict will be only the beginning of future insect management. Here ends our prognostication.

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# APPENDIX I: ACQUISITION AND ADMINISTRATION OF EASTERN REGION NATIONAL FORESTS

Those readers who wish to trace further the various kinds of projects that have taken place in Eastern Region national forests should be aware of the regional name and boundary changes as well as forest name changes and consolidations. Such an awareness will help researchers in contacting the appropriate Federal Regional Record Centers as well as in searching the National Archives.

The Forest Service Regions, called Districts until 1930, were initially administered by Regional (District) Foresters stationed in Washington, DC. In 1908, the Regional Foresters were transferred to field headquarters—except for the R-7 Regional Forester, who remained in Washington. He was transferred to the field in 1934.

The three Lake States—Minnesota, Wisconsin, and Michigan—were part of the Rocky Mountain Region (R-2), headquartered in Denver, CO, from 1908 to the end of 1928—except for a brief period from March 1909 to February 1913. During this latter period, the Lake States were part of the Northern Region (R-1), headquartered in Missoula, MT. The remaining northeastern States were part of what was then the Eastern Region (R-7).

Region 9 was formed on December 22, 1928, and was called the Lake States Region until 1932 (fig. 3). The States of Indiana, Illinois, Iowa, Missouri, and Ohio were transferred from Region 7 to Region 9 in 1930. In 1932, Region 9's name was changed to North Central Region (fig. 4). The final change occurred on March 1, 1966, when Region 7 was abolished and the States from Maine to Maryland and Ohio were added to Region 9 (table 4). Also, Region 9 was given the former name of Region 7—the Eastern Region. The State of North Dakota was part of Region 9 from January 3, 1930, until the 1966 changes took place. (After 1917 when the Dakota National Forest was abolished, the State did not contain any National Forests.)

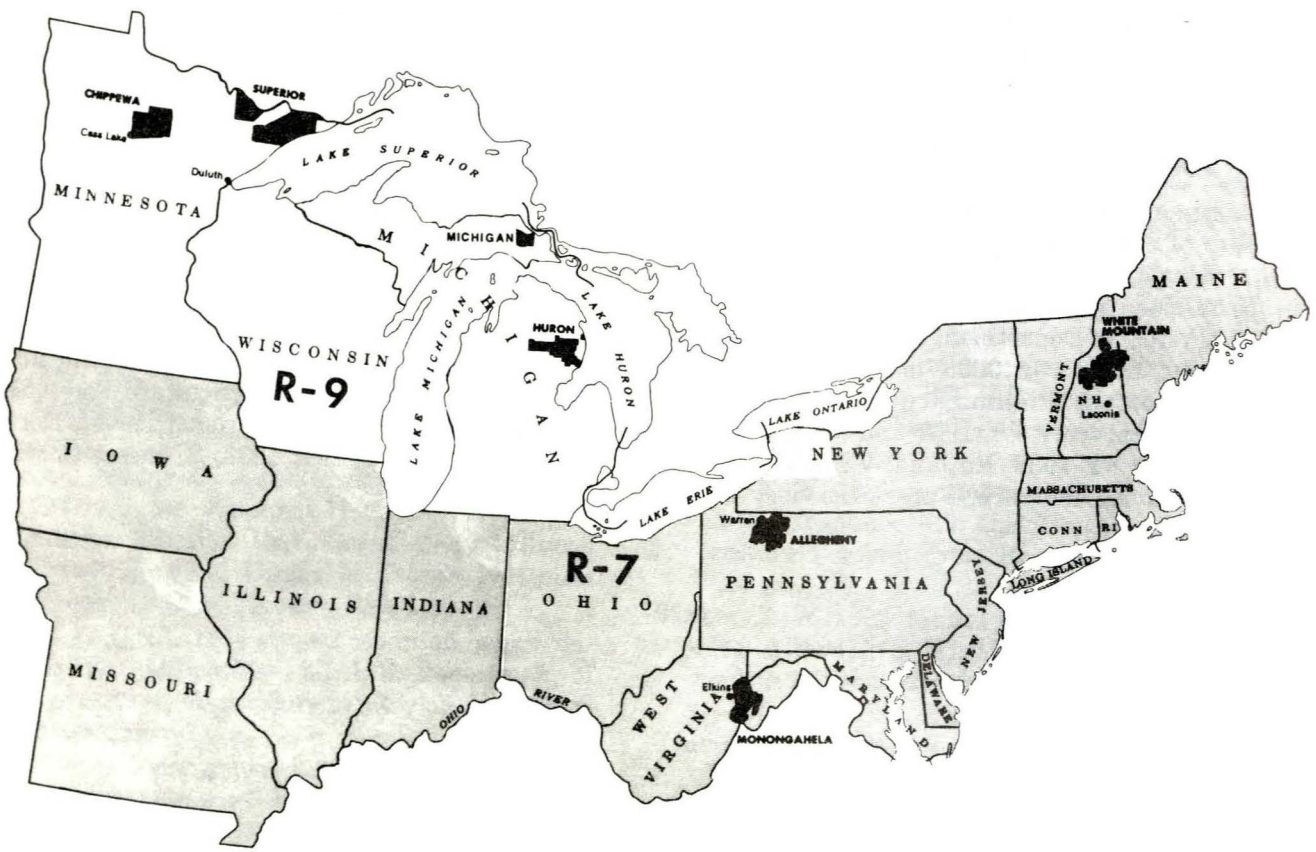


Figure 3.—*National forests of the Northeastern States, 1928-1932. Region 9 is the Lake States Region and Region 7 is the Eastern Region.*

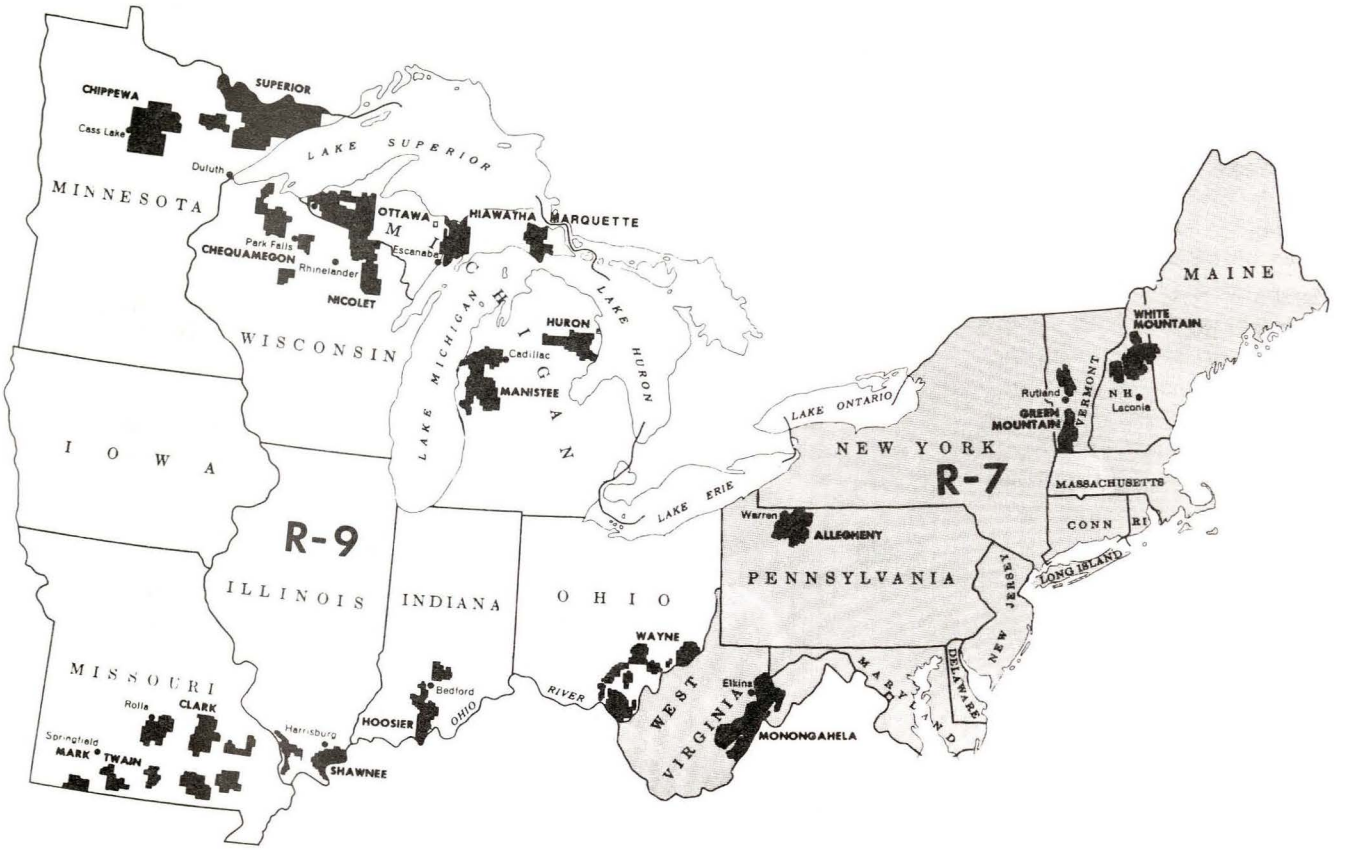


Figure 4.—*National forests of the Northeastern States, 1932-1966. Region 9 is the North Central Region and Region 7 is the Eastern Region.*

Table 4.—*Eastern Region National Forest acquisition dates, name changes, and consolidations*

| National forest | Year acquired[a] | Notes |
|---|---|---|
| **LAKE STATES** | | |
| Chequamegon | 1928 | |
| Chippewa | 1902 | Called Minnesota NF until June 22, 1928. |
| Hiawatha (Marquette 1909) | 1928 | East Unit: Established as Marquette NF on February 10, 1909; made part of Michigan NF in 1915; name changed back to Marquette NF in 1928. The Marquette was abolished February 9, 1962, and made part of the Hiawatha NF.<br><br>West Unit: Established in 1928. Around 1935, the Hiawatha and Marquette were combined administratively and were referred to as Upper Michigan National Forests until 1962. |
| Huron | 1909 | Established as Michigan NF; name changed to Huron NF in 1928. On May 10, 1945, the Huron was consolidated administratively with the Manistee; they were called Lower Michigan National Forests. In 1962, the name was changed to Huron-Manistee National Forests. |
| Manistee | 1933 | (See notes about consolidation under Huron NF.) |
| Nicolet | 1928 | |
| Ottawa | 1928 | |
| Superior | 1902 | |
| **MIDLANDS** | | |
| Hoosier | 1933 | (See notes under Wayne NF.) |
| Mark Twain (Clark 1933) | 1935 | In September 1953, the Clark and Mark Twain were combined administratively and called the Missouri National Ranger Districts were transferred to the Shawnee.) In 1962, the forests again divided into the Clark and Mark Twain and the Ranger Districts were returned. On June 30, 1973, the name "Clark" was abolished and the forest was made part of Mark Twain NF. |
| Shawnee | 1933 | (See Ranger District transfers under Mark Twain.) |
| **NORTHERN APPALACHIA** | | |
| Allegheny | 1920 | |
| Monongahela | 1915 | |
| Wayne | 1934 | On August 20, 1949, the Wayne combined administratively with the Hoosier NF; they were called Wayne-Hoosier Purchase Units. In 1951 each unit was proclaimed a national forest but they remained combined. |
| **NEW ENGLAND** | | |
| Green Mountain | 1928 | |
| White Mountain | 1914 | |

[a]Year given is earliest date of the forest (e.g., when obtained from public domain land, as forest reserves (1902), by purchase or transfer, etc.).

# APPENDIX II: SUPPRESSION OF TARGET INSECTS

This appendix delineates (in descending order of total regional acres treated) the insects receiving specific insecticide treatment by subregion, national forest, year, and the results obtained. "Year treated" refers to calendar year (CY) throughout this report; when information was taken from fiscal year (FY) reports, it was placed with (CY) information. Dashes (—) in various columns indicate that no data were available or that records were incomplete. Under "acres treated," "0+" indicates that we have a document reporting that treatment occurred, but the document gives no data on exact acreage. E-coded numbers indicate treatment was experimental. Under "Results," percentages and quoted descriptions (e.g., 90 percent, "satisfactory") were taken directly from available documents. (For the most part, these are not scientific judgments, and we had no guidelines to help us determine their consistency.) Unquoted descriptions are inferences made by the authors when reports were not specific.

Insecticides have been applied by a variety of means. The "Application method" classifications in Appendix II are defined as follows:

Aircraft — insecticide is applied as a liquid; this classification includes both fixed-wing airplanes and helicopters.

Mistblower — insecticide is injected into a fast-moving large-volume air flow; this classification includes both vehicle-mounted and back-pack equipment.

Hydraulic sprayer — insecticide is carried in a large volume of liquid; this sprayer is mounted on or pulled by a vehicle.

Hand sprayer — back-pack, knapsack, or similar hydraulic sprayer carried by a person; this classification includes a modified back-pack sprayer fitted with a wand for inserting insecticide into soil.

Planting machine — insecticide is dispersed into furrows during tree planting; the insecticide dispersal equipment is attached to the tree planting machine.

Dipped stock — tree roots (planting stock) are dipped into an insecticide before planting.

Broadcast on ground — insecticide, e.g., bait, is spread on the ground surface manually or by machine.

## SARATOGA SPITTLEBUG

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **LAKE STATES** | | | |
| Chequamegon | 1949 | DDT | — | Mistblower | 55 | 90 |
| | 1951 | DDT | 1 | Aircraft | 70 | 95 |
| | 1951 | DDT | 0.5 | Mistblower | 80 | 95 |
| | 1952 | DDT | 1 | Aircraft | 618 | 95 |
| | 1952 | DDT | — | Mistblower | 200 | 95 |
| | 1953 | DDT | 1 | Aircraft | 1,921 | 90 |
| | 1954 | DDT | 1 | Aircraft | 3,459 | 86-100 |
| | 1955 | DDT | 1 | Aircraft | 2,195 | "good" |
| | 1956 | DDT | 1 | Aircraft | 773 | "satisfactory" |
| | 1957 | DDT | 1 | Aircraft | 544 | "satisfactory" |
| | 1958 | DDT | 1 | Aircraft | 755 | "satisfactory" |
| | 1959 | DDT | 1 | Aircraft | 575 | — |
| | 1961 | DDT | 1 | Aircraft | 43 | — |

(Table continued on next page)

(Table Continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | 1962 | DDT | 1 | Aircraft | 155 | 90 |
| | 1963 | DDT | 1 | Aircraft | 165 | — |
| | 1968 | Malathion | 0.75 | Aircraft | 3 | — |
| | 1969 | Malathion | 0.75 | Aircraft | 528 | 96-100 |
| | | | | | Total 12,139 | |
| Hiawatha | 1948 | DDT | 1 | Aircraft | 480 | 98-99 |
| | 1949 | DDT | — | Mistblower | 300 | — |
| | 1950 | DDT | 1 | Aircraft | 407 | 90 |
| | 1953 | DDT | 1 | Aircraft | 1,028 | 98 |
| | 1954 | DDT | 1 | Aircraft | 575 | 99-100 |
| | 1955 | DDT | 1 | Aircraft | 357 | "good control" |
| | 1957 | DDT | 1 | Aircraft | 633 | "satisfactory" |
| | 1958 | DDT | 1 | Aircraft | 66 | 100 |
| | 1959 | DDT | 1 | Aircraft | 324 | "satisfactory control" |
| | 1960 | DDT | 1 | Aircraft | 706 | "adequately controlled" |
| | 1969 | Malathion | 0.60 | Aircraft | 90 | — |
| | | | | | Total 4,966 | |
| Huron | 1961 | DDT | 1 | Aircraft | 192 | — |
| | 1962 | DDT | 1 | Aircraft | 680 | 90-99+ |
| | 1963 | DDT | 1 | Aircraft | 4,253 | averaged 89 |
| | 1964 | DDT | 1 | Mistblower | 4-E | 99+ |
| | 1964 | Malathion | 1 | Mistblower | 4-E | 99+ |
| | 1964 | Malathion | 0.5 | Mistblower | 4-E | 99 |
| | 1965 | Malathion | 1 | Aircraft | 50-E | 99+ |
| | 1965 | Malathion | 0.5 | Aircraft | 50-E | 25 |
| | 1965 | Malathion | 0.75 | Aircraft | 35-E | 99+ |
| | 1966 | Malathion | 0.6 | Aircraft | 400 | averaged 93 |
| | 1969 | Malathion | 0.75 | Aircraft | 4,908 | 83-100 |
| | | | | | Total 10,580 | |
| Manistee | 1946 | DDT | 1 & 2 | Aircraft | 710-E | 95 |
| | 1948 | DDT | 1 | Aircraft | 80 | 95 |
| | 1949 | DDT | 0.6 | Mistblower | 64-E | 62-94 |
| | 1949 | DDT | 0.5 | Mistblower | 30-E | 80-90 |
| | 1950 | DDT | 0.75 | Mistblower | 124 | 95 |
| | 1950 | DDT | — | — | 195 | — |
| | 1951 | DDT | — | Mistblower and hand sprayer | 310 | — |
| | 1952 | DDT | — | Mistblower | 215 | 95 |
| | 1959 | DDT | 1 | Aircraft | 134 | "satisfactory control" |
| | | | | | Total 1,862 | |
| Nicolet | 1945 | DDT | 0.25 | Aircraft | 66-E | 0 |
| | 1945 | DDT | 0.5 | Aircraft | 80-E | 31 |
| | 1945 | DDT | 1 | Aircraft | 313-E | 36 |
| | 1945 | DDT | 2 | Aircraft | 10-E | 61 |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | 1945 | DDT | 5 | Aircraft | 9-E | 96-100 |
| | 1946 | DDT | 0.5 | Aircraft | 118-E | 85-90 |
| | 1946 | DDT | 0.92 | Aircraft | 367-E | 85-90 |
| | 1946 | DDT | 1 | Aircraft | 458-E | 85-90 |
| | 1946 | DDT | 2 | Aircraft | 657-E | 85-90 |
| | 1947 | DDT | 1 | Aircraft | 200-E | excellent |
| | 1947 | DDT | 2 | Aircraft | 100-E | excellent |
| | 1947 | DDT | 1 | Aircraft | 2,450 | averaged 90 |
| | 1948 | DDT | 1 | Aircraft | 794[a] | "good control" |
| | 1949 | DDT | 1 | Aircraft | 1,522[a] | 90-100 (spit.), 80 (sawfly) |
| | 1949 | DDT | 1 | Hand sprayer | 88[a] | 95+-100 |
| | 1950 | DDT | 1 | Aircraft | 9,250 | 95 |
| | 1951 | DDT | 1 | Aircraft | 4,294 | 71-94 |
| | 1952 | DDT | 1 | Aircraft | 1,743 | 87-100 |
| | 1953 | DDT | 1 | Aircraft | 6,014 | 44-82 |
| | 1954 | DDT | 1 | Aircraft | 2,850 | 37-85 |
| | 1955 | DDT | 1 | Aircraft | 5,538 | "excellent or satisfactory on 10 out of 13 areas" |
| | 1956 | DDT | 1 | Aircraft | 2,098 | "satisfactory" |
| | 1957 | DDT | 1 | Aircraft | 4,710 | "satisfactory on all but two plantations" |
| | 1958 | DDT | 1 | Aircraft | 3,194 | "satisfactory overall" |
| | 1959 | DDT | 1 | Aircraft | 1,602 | "satisfactory control" |
| | 1960 | DDT | 1 | Aircraft | 1,958 | --- |
| | 1961 | DDT | 1 | Aircraft | 2,154 | --- |
| | 1962 | DDT | 1 | Aircraft | 1,564 | 99+ |
| | 1962 | DDT | 0.5 | Aircraft | 160 | 40 |
| | 1962 | DDT | 1 | Hand sprayer | 30 | --- |
| | 1965 | Malathion | 0.13 | Mistblower | 4-E | unsatisfactory |
| | 1965 | Malathion | 0.25 | Mistblower | 4-E | satisfactory |
| | 1965 | Malathion | 0.5 | Mistblower | 4-E | satisfactory |
| | 1967 | Malathion | 0.5 | Aircraft | 149 | --- |
| | 1968 | Malathion | 0.5 | Mistblower | 12 | --- |
| | 1976 | Malathion | 0.75 | Aircraft | 40 | 99 |
| | | | | | Total 54,604 | |
| Ottawa | 1945 | DDT | — | — | 65 | --- |
| | 1946 | DDT | 1 & 2 | Aircraft | 220-E | 80-90 |
| | 1947 | DDT | 1 | Aircraft | 1,320 | 98 |
| | 1949 | DDT | 1 | Aircraft | 2,250 | 95-98 |
| | 1950 | DDT | 1.05 | Aircraft | 440 | 80 |
| | 1950 | DDT | 2 | Hand sprayer | 5-E | --- |
| | 1951 | DDT | 1 | Aircraft | 1,200 | 80 |
| | 1952 | DDT | 1 | Aircraft | 1,120 | 75 |
| | 1953 | DDT | 1 | Aircraft | 2,168 | 85 |
| | 1954 | DDT | 1 | Aircraft | 1,227 | 69-100 |
| | 1954 | DDT | — | Hand sprayer | 13 | 69-100 |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | 1955 | DDT | 1 | Aircraft | 1,570 | "good to excellent" |
| | 1956 | DDT | 1 | Aircraft | 212 | "satisfactory" |
| | 1961 | DDT | 1 | Aircraft | 55 | -- |
| | 1962 | DDT | 0.96 | -- | 30 | -- |
| | 1968 | Malathion | 0.5 | Aircraft | 120 | "satisfactory" |
| | | | | Total | 12,015 | |
| | | | | Regional total | 96,166 | |

[a]Treated for Saratoga spittlebug and redheaded pine sawfly simultaneously were: 251 of the 794 acres, 449 of the 1,522 acres, and 25 of the 88 acres.

## SPRUCE BUDWORM

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **LAKE STATES** | | | |
| Superior | 1957 | DDT | 1 | Aircraft | 90-E | -- |
| | 1958 | DDT | 1 | Aircraft | 140-E | "satisfactory" |
| | 1959 | DDT | 1 | Aircraft | 140-E | "successful" |
| | 1960 | DDT | 1 | Aircraft | 23,990 | "very good" |
| | 1960 | DDT | 0.5 | Aircraft | 354 | "very good" |
| | 1962 | DDT | 1 | Aircraft | 54,660 | 97 |
| | 1962 | DDT | 0.5 | Aircraft | 1,606 | 97 |
| | 1963 | DDT | 0.5 | Aircraft | 3,835 | "excellent" |
| | | | | Regional total | 84,815 | |

## REDHEADED PINE SAWFLY

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| Chequamegon | 1935 | Lead arsenate | -- | -- | 0+ | -- |
| | 1946 | DDT | -- | Hand sprayer | 300 | 90-95 |
| | 1947 | DDT | 1 | Aircraft | 1,025 | 30-100 |
| | 1947 | DDT | 0.5 | Aircraft | 1,025 | 0-50 |
| | 1947 | DDT | 0.25 | Hand sprayer | 1,593 | 90-98 |
| | 1948 | DDT | 0.09 | Hand sprayer | 1,685 | 90 |
| | 1949 | DDT | 0.17 | Hand sprayer | 2,533 | 90 |
| | 1949 | DDT | 0.19 | Hand sprayer | 425 | 90 |
| | 1949 | DDT | 0.21 | Hand sprayer | 700 | 90 |
| | 1949 | DDT | 0.25 | Hand sprayer | 50 | 90 |
| | 1950 | DDT | -- | Mistblower | 35 | 90 |
| | 1950 | DDT | -- | Hand sprayer | 748 | 90 |
| | 1951 | DDT | -- | Hand sprayer | 110 | 95 |
| | 1960 | DDT | -- | Hand sprayer | 40 | successful |
| | | | | Total | 10,269+ | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| Chippewa | 1939 | Lead arsenate | — | Hand sprayer | 11 | — |
| | 1948 | DDT | — | Hand sprayer | 93 | 90 |
| | 1949 | DDT | — | Hand sprayer | 95 | "good" |
| | 1953 | DDT | — | Hand sprayer | 50 | 80 |
| | | | | | Total 249 | |
| Hiawatha | 1936 | Lead arsenate | — | Hand sprayer | 454 | "effective" |
| | 1938 | Lead arsenate | 0.03 | Hand sprayer | 2,260 | satisfactory |
| | 1938 | Lead arsenat | — | Hand sprayer | 1,587 | — |
| | 1939 | Lead arsenate | 0.71 | Hand sprayer | 1,388 | — |
| | 1940 | Lead arsenate | 0.05 | Hand sprayer | 1,404 | — |
| | 1945 | DDT | — | Hand sprayer | 1,935 | — |
| | 1946 | Lead arsenate | — | Hand sprayer | 2,125 | "satisfactory" |
| | 1946 | DDT | — | Hand sprayer | 640 | 90-95 |
| | 1947 | DDT | — | Hand sprayer | 1,233 | 80-95 |
| | 1948 | DDT | 1 | Hand sprayer | 965 | 60-99 |
| | 1957 | DDT | — | Hand sprayer | 236 | 100 |
| | 1958 | DDT | 1 | Aircraft | 54 | 100 |
| | 1959 | DDT | — | Hand sprayer | 47 | — |
| | 1960 | DDT | 1 | Aircraft | 88 | successful |
| | 1960 | DDT | — | Hand sprayer | 10 | — |
| | 1969 | Malathion | 1 | Hand sprayer | 3 | 100 |
| | | | | | Total 14,429 | |
| Huron | 1935 | Lead arsenate | — | Hand sprayer | 0+ | "not very satisfactory" |
| | | | | | Total 0+ | |
| Manistee | 1934 | Lead arsenate | — | — | 0+ | — |
| | 1935 | Lead arsenate | — | — | 0+ | — |
| | 1936 | Lead arsenate | — | Hydraulic sprayer | 0+ | "very effective" |
| | 1938 | Lead arsenate | — | — | 10,048 | satisfactory |
| | 1939 | Lead arsenate | — | — | 10,636[a] | — |
| | 1939 | Lead arsenate and Nicotine sulphate | — | — | 300[b] | — |
| | 1939 | Nicotine sulphate | — | — | 680[b] | — |
| | 1940 | Lead arsenate | — | Hydraulic sprayer | 177 | — |
| | 1946 | DDT | 1.7 | Aircraft | 1,800-E | "satisfactory" |
| | 1946 | DDT | — | Hand sprayer | 800-E | 99 |
| | 1947 | DDT | 1 | Aircraft | 3,224 | 30-99 |
| | 1947 | DDT | — | Mistblower | 0+-E | "effective" |
| | 1947 | DDT | — | Hand sprayer | 25 | — |
| | 1948 | DDT | 1 | Aircraft | 2,240 | 80-90 |
| | 1948 | DDT | — | Hand sprayer | 300 | 80 |
| | 1951 | DDT | — | Hand sprayer | 12 | 95 |
| | 1958 | DDT | — | Hand sprayer | 30 | "satisfactory" |
| | 1960 | Malathion | 2 | Aircraft | 202 | — |
| | 1969 | Malathion | 1 | Hydraulic sprayer | 50-E | 99 |
| | 1970 | Malathion | 0.75 | Aircraft | 45-E | 100 |
| | | | | | Total 30,569+ | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| Nicolet | 1947 | Lead arsenate | --- | Hand sprayer | 87 | "heavy kill" |
| | 1947 | DDT | --- | --- | 0+ | --- |
| | 1948 | DDT | 1 | Aircraft | 549[c] | 80-99 |
| | 1948 | DDT | 1 | Hand sprayer | 452 | 95-99+ |
| | 1949 | DDT | 1 | Aircraft | 449[c] | 80 (sawfly), 90-100 (spit.) |
| | 1949 | DDT | 1 | Hand sprayer | 332[c] | 75-100 |
| | 1958 | DDT | 1 | Aircraft | 20 | "satisfactory" |
| | 1958 | DDT | --- | Hand sprayer | 21 | --- |
| | 1966 | Malathion | 0.8 | Mistblower | 14 | "excellent" |
| | | | | | Total 1,924+ | |
| Ottawa | 1947 | DDT | --- | Hand sprayer | 25 | 100 |
| | 1949 | DDT | --- | Hand sprayer | 3 | 100 |
| | 1970 | Malathion | 0.5 | Mistblower | 1-E | 84-100 |
| | | | | | Total 29 | |
| | | | **MIDLANDS** | | | |
| Mark Twain | 1941 | Lead arsenate | --- | --- | 0+ | --- |
| | 1949 | DDT | --- | Hand sprayer | 186 | 95 |
| | 1953 | DDT | --- | --- | 8 | "no new infestation" |
| | | | | | Total 194+ | |
| Shawnee | 1946 | DDT | 1 | Hand sprayer | 113 | 80-90 |
| | 1947 | DDT | 0.5 & 1 | Aircraft | 5,267 | 5-85 |
| | 1947 | DDT | 1 | Aircraft | 447-E | "erratic" |
| | 1947 | DDT | 0.5 | Aircraft | 438-E | "erratic" |
| | 1947 | DDT | 0.25 | Aircraft | 64-E | "erratic" |
| | 1948 | DDT | --- | Hand sprayer | 8 | 80-100 |
| | 1949 | DDT | --- | Hand sprayer | 30 | 80-85 |
| | | | | | Total 6,367 | |
| | | | **NORTHERN APPALACHIA** | | | |
| Monongahela | 1951 | --- | --- | Hand sprayer | 10 | 50 |
| | | | | | Total 10 | |
| Wayne | 1941 | Lead arsenate | --- | Hand sprayer | 186 | satisfactory |
| | | | | | Total 186 | |
| | | | | | Regional total 64,226+ | |

[a]Of the 10,636 acres, 4,260 were treated for redheaded and jack pine sawflies simultaneously.
[b]Treated for redheaded and jack pine sawflies simultaneously.
[c]Treated for redheaded pine sawfly and Saratoga spittlebug simultaneously were 251 of the 549 acres, all of the 449 acres, and 25 of the 332 acres.

## JACK PINE BUDWORM

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **LAKE STATES** | | | |
| Chequamegon | 1957 | DDT | 1 | Aircraft | 14,421 | "very satisfactory" |
| | 1961 | DDT | 1 | Aircraft | 2,400 | 78+ |
| | 1968 | Mexacarbate | 0.15 | Aircraft | 500-E | unsatisfactory |
| | 1968 | Aminocarb | 0.15 | Aircraft | 500-E | "satisfactory" |
| | | | | | Total 17,821 | |
| Chippewa | 1939 | Lead arsenate | — | Hydraulic sprayer | 0+ | — |
| | 1959 | DDT | 1 | Aircraft | 600 | "successful" |
| | 1960 | DDT | 1 | Hydraulic sprayer | 1,030 | "very good control" |
| | 1962 | DDT | 1 | Aircraft | 24,055 | 98 |
| | | | | | Total 25,685+ | |
| Hiawatha | 1950 | DDT | 1 | Aircraft | 320 | 95 |
| | 1951 | DDT | 1 | Aircraft | 4,358 | 95 |
| | 1962 | DDT | 1 | Aircraft | 12,598 | satisfactory |
| | | | | | Total 17,276 | |
| Huron | 1964 | Malathion | 1 | Aircraft | 80-E | 64 |
| | 1964 | Malathion | 0.5 | Aircraft | 120-E | 43 |
| | | | | | Total 200 | |
| Manistee | 1964 | DDT | 1 | Aircraft | 60-E | 86 |
| | 1964 | Malathion | 1 | Aircraft | 60-E | 85 |
| | 1964 | Malathion | 0.5 | Aircraft | 60-E | 33 |
| | 1964 | Mexacarbate | 1 | Aircraft | 15-E | 85 |
| | 1964 | Dimethoate | 0.5 | Aircraft | 15-E | 95 |
| | 1966 | Malathion | 0.77 | Aircraft | 200-E | 75 |
| | | | | | Total 410 | |
| Superior | 1939 | Lead arsenate | — | Hydraulic sprayer | 0+-E | "unsatisfactory" |
| | | | | | Total 0+ | |
| | | | | | Regional total 61,392+ | |

## MISCELLANEOUS INSECTS

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **GRASSHOPPERS** | | | |
| | | | **LAKE STATES** | | | |
| Hiawatha | 1938 | Arsenicals | — | Broadcast on ground | 140 | "very effective" |
| | 1949 | Ammonium sulphate | — | Broadcast on ground | 30 | 80 |
| | | | | | Total 170 | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| Manistee | 1936 | Sodium arsenate | — | Broadcast on ground | 18,293 | "quite satisfactory" |
| | 1937 | — | — | Broadcast on ground | 14,873 | "quite satisfactory" |
| | 1938 | — | — | Broadcast on ground | 3,025 | — |
| | 1939 | Sodium arsenate | — | Broadcast on ground | 400 | — |
| | 1940 | — | — | Broadcast on ground | 10,288 | satisfactory |
| | 1941 | — | — | Broadcast on ground | 1,944 | — |
| | 1942 | — | — | Broadcast on ground | 0+ | — |
| | 1948 | Sodium fluosilicate | — | Broadcast on ground | 415 | 80 |
| | 1949 | Chlordane | 0.15 | Broadcast on ground | 1,298 | 90 |
| | | | | Total | 50,536+ | |
| | | | | Regional total | 50,706+ | |
| | | | **WHITE GRUBS** | | | |
| | | | **LAKE STATES** | | | |
| Chippewa | 1934 | Lead arsenate | — | Dipped stock | 43-E | "definite protection" |
| | 1934 | Calcium arsenate | — | Dipped stock | 1-E | "definite protection" |
| | | | | Total | 44 | |
| Hiawatha | 1961 | Aldrin | 0.2 | Planting machine | 364 | "erratic" |
| | 1961 | Aldrin | — | Dipped stock | 533 | "erratic" |
| | 1962 | Aldrin | 0.2 | Planting machine | 1,227 | "erratic" |
| | 1962 | Aldrin | 0.3 | Planting machine | 456 | "erratic" |
| | 1962 | Aldrin | — | Dipped stock | 1,191 | "erratic" |
| | 1963 | Aldrin | 0.2 | Planting machine | 105 | "erratic" |
| | 1963 | Aldrin | — | Dipped stock | 2,596 | "erratic" |
| | 1964 | Aldrin | 0.2 | Planting machine | 76 | "erratic" |
| | 1965 | Aldrin | 0.2 | Planting machine | 885 | "erratic" |
| | 1965 | Aldrin | 0.2 | Hand sprayer | 342 | "erratic" |
| | 1966 | Aldrin | 0.2 | Planting machine | 785 | "erratic" |
| | 1966 | Aldrin | 0.2 | Hand sprayer | 259 | "erratic" |
| | 1966 | Aldrin | 0.1 | Hand sprayer | 297 | "erratic" |
| | 1966 | Aldrin | 0.1 | Planting machine | 80 | "erratic" |
| | 1967 | Aldrin | 0.2 | Planting machine | 552 | — |
| | 1967 | Aldrin | 0.2 | Hand sprayer | 86 | — |
| | 1967 | Aldrin | 3.2 | Planting machine | 140 | — |
| | 1967 | Aldrin | 0.1 | Planting machine | 2-E | satisfactory |
| | 1967 | Aldrin | 0.3 | Planting machine | 3-E | satisfactory |
| | 1967 | Aldrin | 0.1 | Hand sprayer | 2-E | satisfactory |
| | 1967 | Aldrin | 0.2 | Hand sprayer | 3-E | satisfactory |
| | 1967 | Aldrin | 3.2 | Planting machine | 5-E | satisfactory |
| | | | | Total | 9,989 | |
| Nicolet | 1960 | Aldrin | — | Dipped stock | 516 | — |
| | 1961 | Aldrin | — | Dipped stock | 365 | — |
| | 1962 | Aldrin | — | Dipped stock | 1,488 | — |
| | | | | Total | 2,369 | |
| Ottawa | 1962 | Aldrin | — | Dipped stock | 232 | — |
| | | | | Total | 232 | |
| | | | | Regional total | 12,634 | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **PINE TUSSOCK MOTH** | | | |
| | | | **LAKE STATES** | | | |
| Chequamegon | 1962 | DDT | 1 | Aircraft | 8,735 | 87-99 |
| | | | | Regional total | 8,735 | |
| | | | **JACK PINE SAWFLY** | | | |
| | | | **LAKE STATES** | | | |
| Manistee | 1939 | Lead arsenate | — | — | 4,260[a] | — |
| | 1939 | Lead arsenate and Nicotine sulphate | — | — | 300[a] | — |
| | 1939 | Nicotine sulphate | — | — | 680[a] | — |
| | | | | Regional total | 5,240 | |
| | | | **SPRUCE BEETLE** | | | |
| | | | **NEW ENGLAND** | | | |
| Green Mountain | 1937 | Copper sulphate | — | Injection | 4,719 | "not effective" |
| | | | | Regional total | 4,719 | |
| | | | **FOREST TENT CATERPILLAR** | | | |
| | | | **LAKE STATES** | | | |
| Chippewa | 1936 | Lead arsenate | — | Hydraulic sprayer | 8 | "successful" |
| | 1937 | Lead arsenate | — | Hydraulic sprayer | 442 | "very satisfactory" |
| | 1938 | Lead arsenate | — | Hydraulic sprayer | 47 | successful |
| | 1951 | DDT | 1 | Aircraft | 664 | 80 |
| | 1952 | DDT | 1 | Aircraft | 519 | 80 |
| | | | | Total | 1,680 | |
| Superior | 1936 | Lead arsenate | 11.2 | Hydraulic sprayer | 195 | "very successful" |
| | 1937 | Lead arsenate | 10.8 | Hydraulic sprayer | 80 | "excellent" |
| | 1937 | Lead arsenate | 9.9 | Hydraulic sprayer | 155 | "excellent" |
| | 1938 | Lead arsenate | — | Hydraulic sprayer | 22 | successful |
| | | | | Total | 452 | |
| | | | | Regional total | 2,132 | |
| | | | **GYPSY MOTH** | | | |
| | | | **LAKE STATES** | | | |
| Manistee | 1974 | Carbaryl | 0.8 | Aircraft | 800 | successful |
| | | | | Total | 800 | |
| | | | **NEW ENGLAND** | | | |
| White Mountain | 1954 | DDT | 1 | Aircraft | 410 | — |
| | 1970 | Carbaryl | 1 | Mistblower | 15 | — |
| | 1972 | Carbaryl | 1 | Mistblower | 12 | — |
| | | | | Total | 437 | |
| | | | | Regional total | 1,237 | |
| | | | **LOBLOLLY PINE SAWFLY** | | | |
| | | | **MIDLANDS** | | | |
| Mark Twain | 1965 | Malathion | — | — | 0+ | "partial control" |
| | | | | Total | 0+ | |
| Shawnee | 1957 | DDT | 1 | Aircraft | 1,135 | 96-100 |
| | | | | Total | 1,135 | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | | Regional total | 1,135+ | |
| | | | **EUROPEAN PINE SHOOT MOTH** | | | |
| | | | **LAKE STATES** | | | |
| Manistee | 1952 | DDT | — | Mistblower | 108 | 90 |
| | 1957 | DDT | 7 | Hydraulic sprayer | 84-E | 90 |
| | 1958 | DDT | 7 | Mistblower | 53 | "fair" |
| | 1958 | DDT | 10 | Mistblower | 150 | "fair to very good" |
| | 1960 | Malathion | 2 | — | 404 | "not satisfactory" |
| | 1960 | Naled | — | — | 14 | — |
| | 1962 | DDT | 2 | Hydraulic sprayer | 10-E | 72 and 84 |
| | 1962 | DDT | 2 | Mistblower | 4-E | 36 |
| | 1962 | DDT | 4.5 | Mistblower | 3-E | 0 |
| | | | | Total | 830 | |
| | | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 1951 | DDT | 4 | Aircraft | 71 | "disappointing" |
| | 1959 | Phorate | 2 | Aircraft | 20-E | "successful" |
| | 1959 | Malathion | 1 | Aircraft | 25-E | 95 |
| | | | | Total | 116 | |
| | | | | Regional total | 946 | |
| | | | **WHITE PINE WEEVIL** | | | |
| | | | **LAKE STATES** | | | |
| Chequamegon | 1963 | Lindane | — | — | 0+ | — |
| | | | | Total | 0+ | |
| Manistee | 1950 | DDT | 1 | Aircraft | 80-E | 78+ |
| | 1950 | DDT | 2 | Aircraft | 320-E | 99 |
| | 1951 | DDT | — | Aircraft | 0+ | — |
| | | | | Total | 400+ | |
| Nicolet | 1962 | Lindane | 0.13 | Mistblower | 5-E | "little control" |
| | 1962 | Lindane | 0.05 | Mistblower | 5-E | "little control" |
| | | | | Total | 10 | |
| Ottawa | 1958 | Lindane | 0.05 | Hand sprayer | 23-E | 100 |
| | 1959 | Lindane | 1 | Aircraft | 50-E | — |
| | 1959 | Lindane | 0.13 | Hand sprayer | 3-E | — |
| | 1962 | Lindane | 0.05 | Mistblower | 5-E | "no signficant reduction" |
| | 1962 | Lindane | 0.03 | Mistblower | 5-E | "no significant reduction" |
| | | | | Total | 86 | |
| | | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 1958 | Lead arsenate | — | Hand sprayer | 75 | — |
| | 1959 | DDT | 2 | Aircraft | 115-E | "effective" |
| | | | | Total | 190 | |
| | | | | Regional total | 686+ | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **LARCH SAWFLY** | | | |
| | | | **LAKE STATES** | | | |
| Chippewa | 1948 | DDT | 0.6 | Aircraft | 100-E | "not conclusive" |
| | 1949 | DDT | 1 | Aircraft | 80-E | "quite effective" |
| | | | | | Total 180 | |
| Superior | 1950 | DDT | 1 | Aircraft | 200-E | 62-70 |
| | | | | | Total 200 | |
| | | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 1940 | Lead arsenate | — | Hand sprayer | 4 | — |
| | 1941 | Lead arsenate | — | Hand sprayer | 4 | — |
| | 1967 | Malathion | 0.7 | Aircraft | 54 | — |
| | 1967 | Malathion | 0.8 | Aircraft | 54 | — |
| | | | | | Total 116 | |
| Monongahela | 1959 | DDT | — | — | 1 | 100 |
| | 1965 | Malathion | — | — | 0+ | — |
| | | | | | Total 1+ | |
| | | | | | Regional total 497+ | |
| | | | **CHERRY SCALLOPSHELL MOTH** | | | |
| | | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 1974 | Carbaryl | 1 | Aircraft | 150-E | — |
| | 1974 | Carbaryl | 2 | Aircraft | 75-E | — |
| | | | | | Regional total 225 | |
| | | | **WALKINGSTICK** | | | |
| | | | **LAKE STATES** | | | |
| Nicolet | 1950 | DDT | 1 | Aircraft | 210 | 99 |
| | | | | | Regional total 210 | |
| | | | **REDHUMPED OAKWORM** | | | |
| | | | **LAKE STATES** | | | |
| Manistee | 1973 | Resmethrin | 0.03 | Aircraft | 30-E | — |
| | 1973 | Malathion | 0.9 | Aircraft | 30-E | — |
| | 1973 | Carbaryl | 1 | Aircraft | 30-E | "most effective" |
| | 1973 | Mexacarbate | 1.5 | Aircraft | 30-E | — |
| | | | | | Regional total 120 | |
| | | | **BLACK TURPENTINE BEETLE MIDLANDS** | | | |
| Mark Twain | 1960 | Orthodichlorobenzene | — | — | 12 | — |
| | 1965 | Benzene hexachloride | 0.4 | Hand sprayer | 62 | — |
| | 1967 | Benzene hexachloride | — | Hand sprayer | 0+ | — |
| | | | | | Total 74+ | |
| | | | **NORTHERN APPALACHIA** | | | |
| Monongahela | 1965 | Benzene hexachloride | — | Hand sprayer | 10 | — |
| | | | | | Total 10 | |
| | | | | | Regional total 84+ | |

(Table continued on next page)

(Table continued)

| National forest | Year treated | Insecticide | Rate | Application method | Acres treated | Results |
|---|---|---|---|---|---|---|
| | | | *Pounds/acre* | | | *Numbers in percent* |
| | | | **YELLOWHEADED SPRUCE SAWFLY** | | | |
| | | | **LAKE STATES** | | | |
| Superior | 1968 | Malathion | 0.5 | Mistblower | 61 | --- |
| | | | | | Regional total 61 | |
| | | | **PINE TORTOISE SCALE** | | | |
| | | | **LAKE STATES** | | | |
| Nicolet | 1954 | DDT | 2 | Aircraft | 25-E | successful |
| | 1954 | Lime sulphur | --- | Hydraulic sprayer | 28 | 90 |
| | | | | | Regional total 53 | |
| | | | **VIRGINIA PINE SAWFLY** | | | |
| | | | **NORTHERN APPALACHIA** | | | |
| Wayne | 1961 | DDT | --- | Mistblower | 2 | "good control" |
| | 1962 | DDT | --- | Mistblower | 7 | --- |
| | 1963 | DDT | --- | Mistblower | 10 | "effective" |
| | 1964 | Malathion | --- | Mistblower | 10 | --- |
| | | | | | Regional total 29 | |
| | | | **RED TURPENTINE BEETLE** | | | |
| | | | **LAKE STATES** | | | |
| Hiawatha | 1966 | Lindane | 0.2 | Hand sprayer | 20 | successful |
| | | | | | Regional total 20 | |
| | | | **EUROPEAN PINE SAWFLY** | | | |
| | | | **MIDLANDS** | | | |
| Hoosier | 1950 | DDT | --- | Hand sprayer | 12 | 96 |
| | | | | | Total 12 | |
| | | | **NORTHERN APPALACHIA** | | | |
| Wayne | 1966 | Malathion | --- | --- | 0+ | --- |
| | | | | | Total 0+ | |
| | | | | | Regional total 12+ | |
| | | | **PITCH PINE TIP MOTH** | | | |
| | | | **NORTHERN APPALACHIA** | | | |
| Monongahela | 1951 | --- | --- | Hand sprayer | 4 | 100 |
| | | | | | Regional total 4 | |
| | | | **NANTUCKET PINE TIP MOTH** | | | |
| | | | **MIDLANDS** | | | |
| Shawnee | 1946 | DDT | --- | --- | 0+-E | --- |
| | 1947 | --- | --- | --- | 1-E | --- |
| | 1948 | DDT | --- | Hand sprayer | 1-E | "excellent" |
| | 1949 | --- | --- | --- | 0+-E | --- |
| | | | | | Regional total 2+ | |
| | | | **FALL CANKERWORM** | | | |
| | | | **NORTHERN APPALACHIA** | | | |
| Allegheny | 1966 | Carbaryl | --- | Aircraft | 0+ | --- |
| | | | | | Regional total 0+ | |

[a]Redheaded and jack pine sawflies were treated simultaneously.

# APPENDIX III

## DDT[34]

The Forest Service is very much interested in any new insecticides or other developments which may be helpful in reducing the heavy drain on forest growth caused by insect infestations. These losses have been very extensive, in some areas the insects destroying valuable stands of timber over thousands of acres. Well known examples are the spruce budworm infestation in the Lake States, the Northeast and Canada, the larch sawfly epidemic which covered the range of eastern larch from the Lake States to the Atlantic, and the bark beetle attacks in the pine stands of the West. Bark beetles, defoliators and other forms of insects harmful to the forests account for a heavy toll, and must be considered along with fire and disease as enemies of the forest. Moreover, insect-killed trees add measurably to the problem of fire control and affect the usefulness and beauty of the forests.

Various control measures have been applied in the past, but there has never been anything in the insecticide field which offered the advantages which may come with DDT. For most insects destroying forest trees there has not been a practical method of control, since highly toxic materials were not available in a form which could be readily applied over large areas. Arsenicals, for example, have offered the most hope, but their use has been of a limited nature because of the cost of materials, the labor needs, and the hazards to all forms of animal life, including man.

The Forest Service, however, is fully aware of the hazards which accompany the use of a potent insecticide. The Service is also cognizant of the public concern over the wide use of a new poison which has not been subjected to exhaustive tests. We appreciate that studies have revealed that all insects are not equally susceptible, that beneficial insects as well as harmful species are killed, and that cold blooded animals are more or less affected. The knowledge that aquatic insects may be wiped out and that trout may be killed have added to the need for careful consideration in the use of DDT in regions where fishing is an important form of recreation.

The answers to the many technical questions should come from the carefully conducted studies of the Bureau of Entomology and Plant Quarantine and the Fish and Wildlife Service. Both of these agencies have conducted studies or made observations on the use of DDT on national forest lands during the past season. Although the Forest Service performs research work in the field of forest management, forest products, and range management, it looks to the Bureau of Entomology and Plant Quarantine for investigations in the field of forest insects, and to the Fish and Wildlife Service for research on forest wildlife. Under this procedure field trials of DDT were carried out by the Bureau of Entomology with the cooperation of the Fish and Wildlife Service and the Forest Service on several national forest areas. These were for Saratoga spittlebug on Jack pine plantations in the Nicolet Forest in Wisconsin, pinetip moth on Ponderosa pine in the Nebraska Forest in Nebraska, and spruce budworm on pine and fir in the Roosevelt National Forest in Colorado. The results of these tests, plus work on other areas have been mentioned here today by representatives of these two Bureaus.

On the forest management side, the Forest Service has been conducting research designed to develop cutting procedures and other practices which would be helpful in controlling harmful insects or in rendering them endemic without recourse to insecticides. In approaching the problem attention has been given to the nature of the attacks, including such factors as age, vigor, composition, past treatment, and growing condition of the forest stand. Two important considerations are kept in mind, (1) what cutting practices can be used to hold the insect epidemics to a minimum, once the attack is expected or already in effect and (2) what treatment within economic limits can be applied in cutting, thinning, and otherwise to develop a natural resistance to the insect attacks. In the case of the spruce budworm for example, it is known that an abundance of good sized balsam fir in a stand consitutes a condition favorable for the development of an epidemic whereas young and vigorous spruce, by themselves, are resistant to attack. Therefore cutting practices which provide for rather frequent cycles, removing all merchantable balsam fir in each cutting, help to maintain a young, highly productive stand resistant to this insect. In fact it has been felt by many workers that the hope for practical and lasting control of many harmful forest insects will be found in the adaptation of cutting practices which will build stand resistance.

[34] *Statement by Lloyd W. Swift, Chief, Division of Wildlife Management, USDA Forest Service, at 41st Annual Convention of the National Audubon Society, New York City, October 22, 1945.*

At this time the Forest Service is in no position to define the limits of usefulness of DDT in its work. We intend to consider fully both its advantages and disadvantages under the widely varying conditions which we have to meet. The insecticide appears to have real promise for application to forest areas by plane, and therefore may be a material which can be used in increasing the productivity of the forests. Information on the effect on destructive insects will be weighed against the conditions on the ground such as the presence or absence of trout waters, and other valuable or unusual wildlife forms. But before its use is fully accepted, the Service would want to know what can be expected under a given set of conditions—what forms of beneficial life, insects, birds, amphibians, fishes, etc. would be endangered and to what extent.

Fowler, Richard F.; Wilson, Louis F.; Paananen, Donna M.
Insect suppression in Eastern Region national forests: 1930-1980. Gen. Tech. Rep. NC-103. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1986. 56 p.

Reports on insect suppression in 16 Eastern Region national forests over a 50-year period. Identifies 27 target insects attacked, insecticides used, acreages treated, and results obtained by suppression attempts. Notes that only 3.4 percent of Eastern national forest land has been chemically treated during the years studied.

KEY WORDS: Pesticides, insecticides, pest management, cultural control, DDT, arsenicals.

1966-86

NORTH CENTRAL

FOREST

EXPERIMENT STATION

20th Anniversary